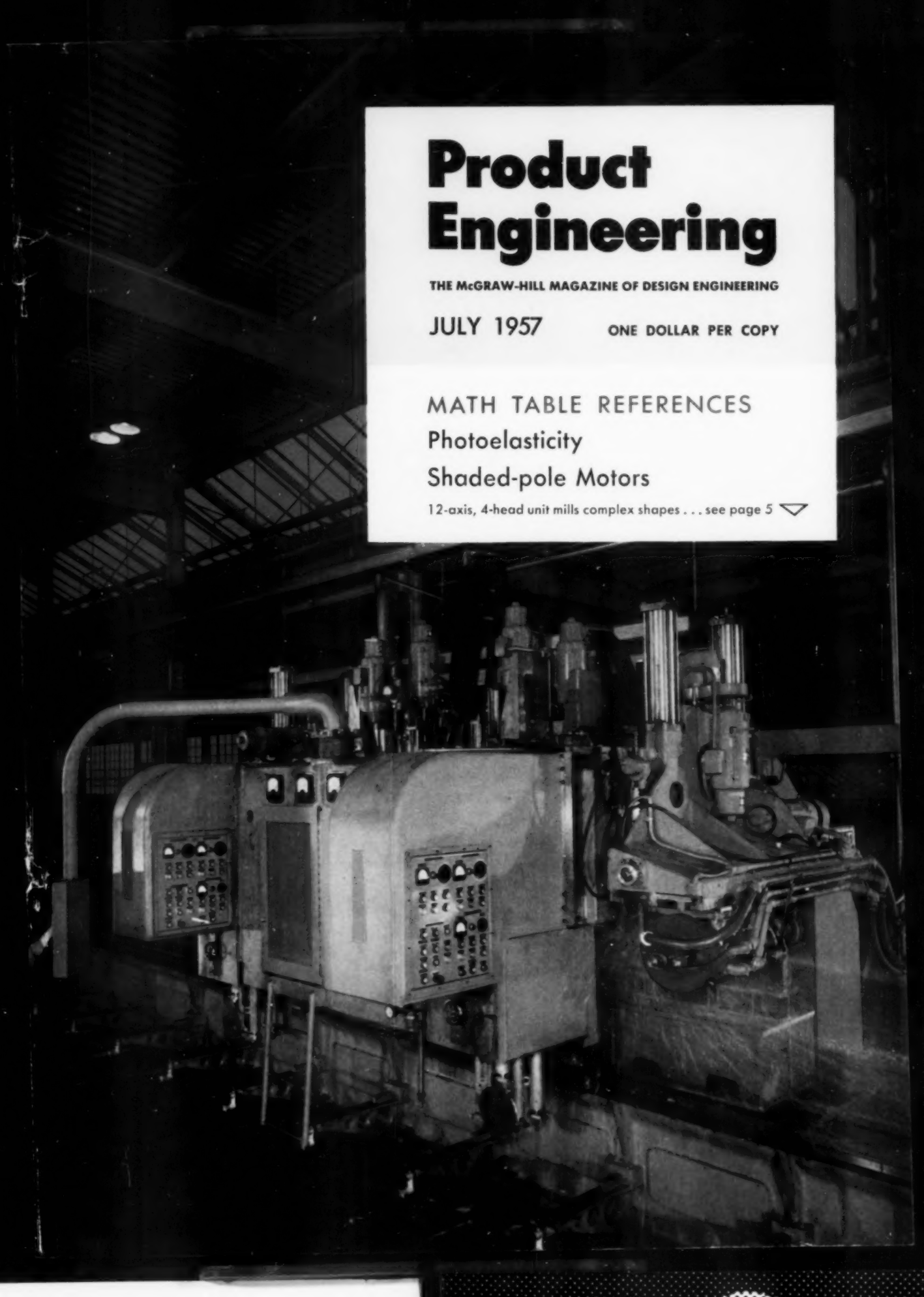


Product Engineering

THE McGRAW-HILL MAGAZINE OF DESIGN ENGINEERING

JULY 1957 ONE DOLLAR PER COPY

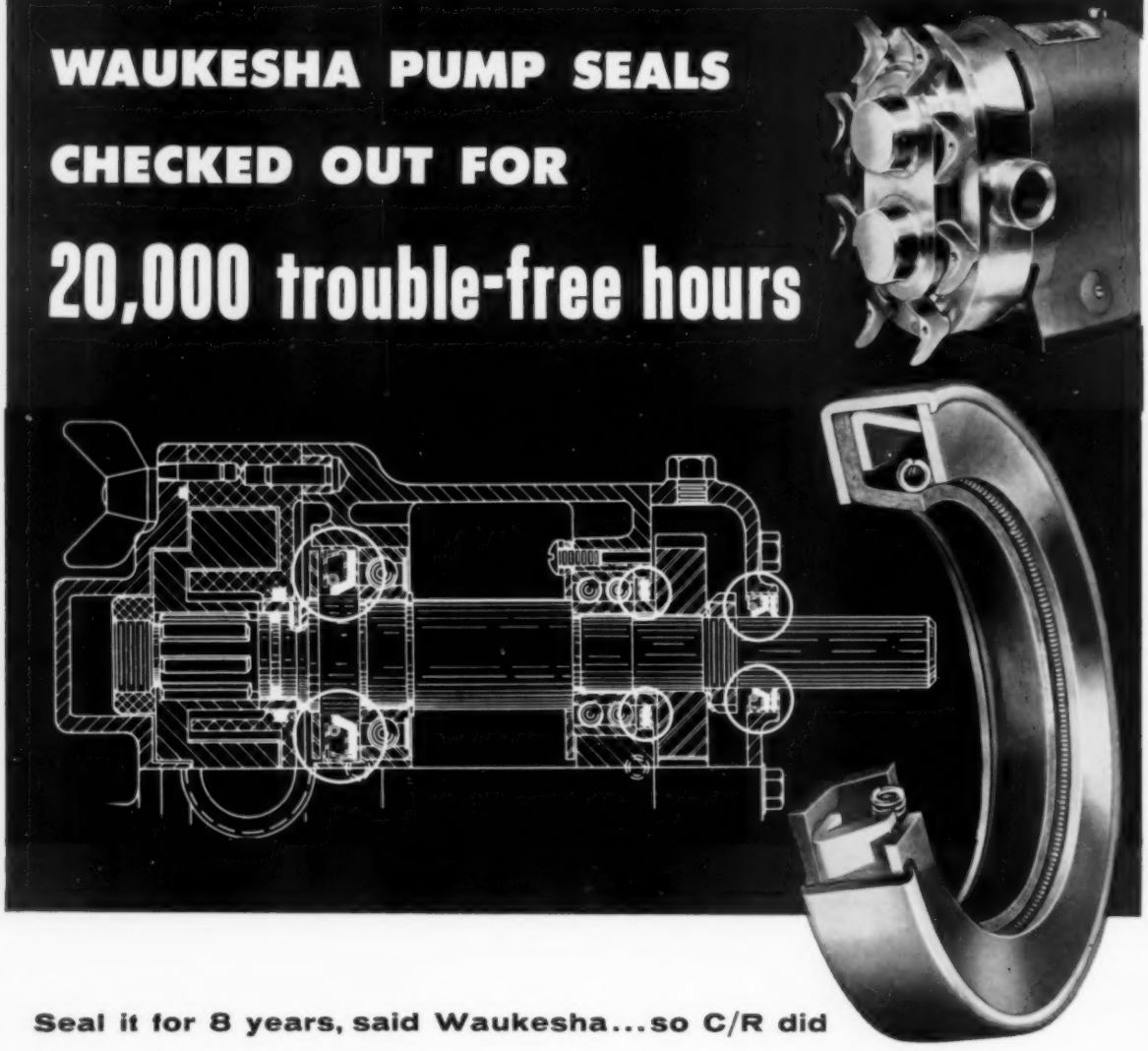
MATH TABLE REFERENCES

Photoelasticity

Shaded-pole Motors

12-axis, 4-head unit mills complex shapes . . . see page 5

WAUKESHA PUMP SEALS CHECKED OUT FOR 20,000 trouble-free hours



Seal it for 8 years, said Waukesha...so C/R did

"And, we might add, we have had very, very few instances of failure with C/R Oil Seals," says Mr. Emil M. Howe, Vice President, Pump Division of the Waukesha Foundry Co. Long service life is only one of the requirements met by the C/R Types P, G and A Oil Seals in this Waukesha Sanitary Pump. They must seal effectively eight hours a day, six days a week for eight years . . . at shaft speeds up to 750 r.p.m., with pump head pressures up to 150 p.s.i., and temperatures ranging from 0° to 220° F., depending on the food material pumped. They also must resist food acids, and the acids and alkalies in the commercial detergents used to cleanse and flush the pump daily. An added indication of C/R Oil Seal dependability in the Waukesha Sanitary Pump is the fact that it constantly must meet rigid 3-A Sanitary Standards for the Dairy and Food Industries.

If you have a sealing problem . . . equally critical . . . or simple . . . bring it to Chicago Rawhide. C/R engineers will help you select the correct oil seal for your application from stock . . . or cooperate with you on special designs.

More automobiles, farm and industrial machines rely on C/R Oil Seals than on any similar sealing device.

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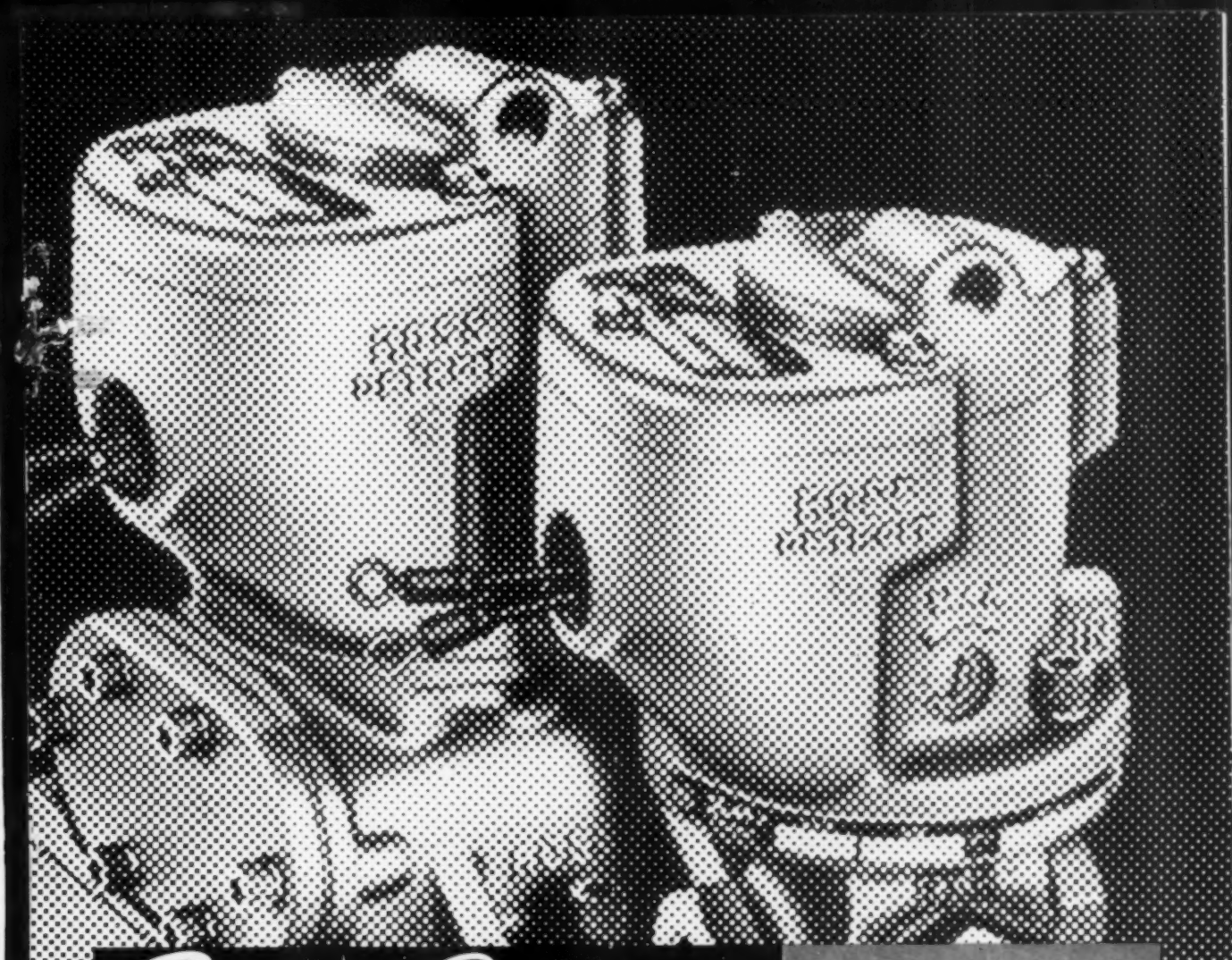

Ross Skyline

Silvermodel JIC Spool Solenoid

Any Skyline Head Attaches to Any Skyline Valve Body

Interchangeable! 25 Million Cycles in Tests!

Now the JIC spool solenoid valves join the Ross Skyline. Now six actuating heads and seven in-line and base mounted bodies—all completely interchangeable—give you any valve you want in this series designed especially to last millions more cycles than ordinary valves. But, these quality valves come to you at *sensible* prices! For instance, the ⅜" Silvermodel base mounted, 4-way is only $62.50 complete, and complies with all JIC requirements. Write for bulletin 315.

Ross OPERATING VALVE COMPANY

120 EAST GOLDEN GATE AVENUE · DETROIT 3, MICHIGAN

Better flavor, better health in every bite . . . thanks, in part, to Monel.

What does this new sea salt have that you need?

Here is a new type of salt. It contains a natural mixture of so-called "trace elements"— tiny amounts of copper and cobalt and magnesium . . . zinc . . . molybdenum . . . manganese . . . calcium . . .

Experts have reason to believe that these trace elements hold the key to many health problems.

Hence a spanking new Texas plant—to produce *Admiral* Sea Salt from Baffin Bay, where the water is almost twice as salty as average sea water.

Plant design engineers faced two potentially serious corrosion problems. Attack on *inside* surfaces of equipment by this extra-salty water . . . and attack on *outside* surfaces by salt-laden breezes.

Use of Monel* nickel-copper alloy avoids both hazards. Monel alloy is one of a family of Inco Nickel Alloys noted for corrosion resistance. Widely used in chemical, petroleum, marine and other industries where acids or alkalies are frequent troublemakers, Monel provides a ready solution to many common problems.

Do you have a problem in which corrosion is a major factor? Or wear? Or high temperatures? Or some destructive combination of conditions? Then send for "Standard Alloys for Special Problems", our guide to the many useful properties and widespread applications of the Inco Nickel Alloys.

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Remember, when you buy

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Whenever you are looking for answers to your metal problems, all the information and help we can give you are yours for the asking. For instance . . .

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- **+ Fabrication Help**
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67 Wall Street New York 5, N. Y.

Nickel Alloys Perform Better, Longer

Product Engineering

THE McGRAW-HILL MAGAZINE OF DESIGN ENGINEERING

July 1957 Vol. 28, No. 7

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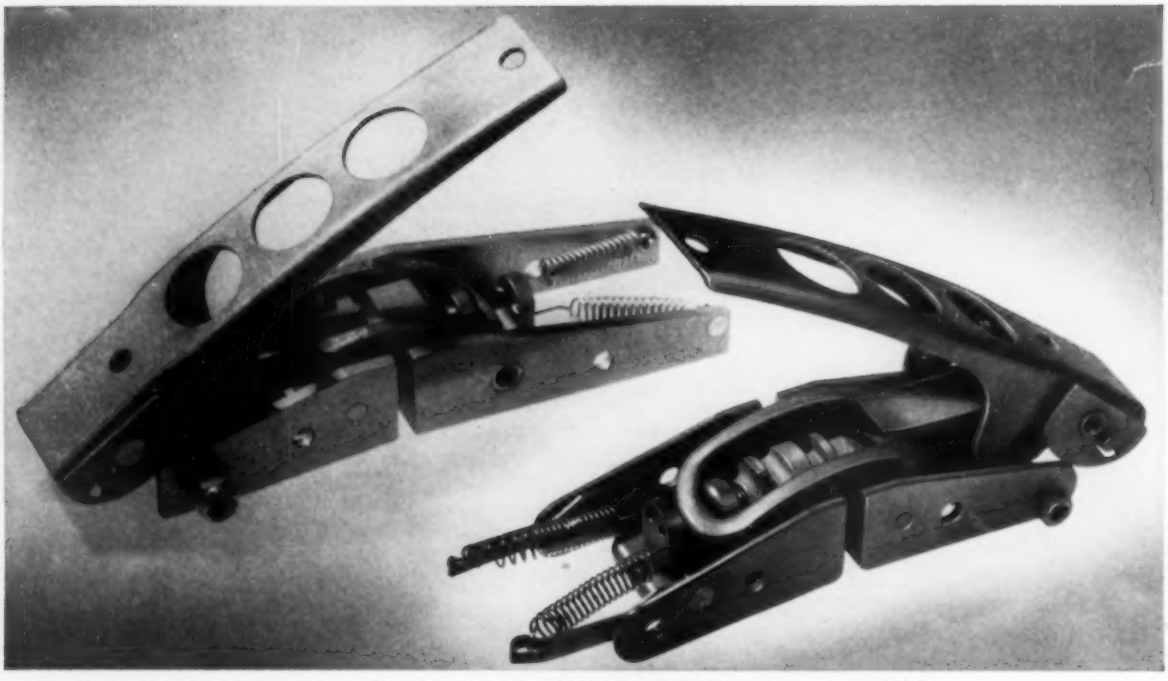
How Designers Solved Fastener Problem with Special Armco Stainless Steels



They look alike. But only the fastener with the Armco 17-4 PH and 17-7 PH parts (right) can be used up to 900 F.

Armco 17-4 PH and 17-7 Stainless Steels give fasteners required strength at 500-900 F, simplify redesign problems.

When Camloc Fastener Corporation's customers switched from propeller-driven to jet planes, they required the same kind of fastener but now it had to stand up against temperatures of 500 to 900 F. Here's how Camloc engineers solved the problem with Armco's new precipitation-hardening stainless steels. Other materials were considered but proved too expensive and too difficult to fabricate.

Replaced Two Metals

The body parts of the fastener, formerly made of a non-ferrous metal, were replaced with precision castings of 17-4 PH. Thinner sections were possible without loss of strength.

Four springs made of Armco 17-7 PH strip and wire are used in the redesigned fastener in place of music wire and high carbon steel parts. The 17-7 PH parts not only have the needed spring properties but withstand the high heat of jet engines. In addition to the excellent mechanical properties and fabricating characteristics of both grades, their good corrosion resistance was a factor of prime importance.

Many Design Advantages

These special Armco Stainless Steels are used in a wide variety of products ranging from garbage disposers to oil well valves, pump shafts, outboard motors, carpenter saws and prime components of America's fastest fighters and bombers.

Consider how *you* can use the unusual combination of properties offered by Armco 17-4 PH and 17-7 PH stainless—high hardness and strength up to 900 F, simple heat treatment, good corrosion resistance and excellent fabricating characteristics.

Armco 17-4 PH is produced in bar, wire and billets; Armco 17-7 PH in those forms as well as sheet, strip and plate. Write us today for complete information on these special Armco Stainless Steels.

ARMCO STEEL CORPORATION

1737 CURTIS STREET, MIDDLETOWN, OHIO

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THIS MONTH'S COVER

Templets control 12 simultaneous feeds on 4 spindles on this Onsrud spar miller. Tracer heads are selsyns driven by a helical screw giving 360° revolution for ½-in. travel; repeatability is 0.002 in. Carriage is driven by a 5-hp adjustable-speed motor. Motors for the two horizontal spindles are 100-hp 3600-rpm; two vertical spindles are 60-hp 7200-rpm. Control system developed by General Electric Specialty Control Department includes 224 electronic tubes.

Interesting to Note . . .

Son of the Earth

In the back of a rectory in Deptford, England, the Reverend William Gregor was enjoying his hobby, geology. He had no idea that his simple dabbling with dirt would one day lead to formation of an industry. In 1790, the 28-year-old clergyman made a routine chemical analysis of a black magnetic sand found in the neighboring parish of Manaccan. To his surprise, the analysis showed that almost half of this soil could not be identified. For want of a better title, he called this strange sand *menaccanite* from the locality he had obtained it, and the unknown substance, *menaccine*.

For five years, nobody was interested in the statements of a clergyman-geologist, that he had found something new. It wasn't until the German chemist, Martin Klaproth, began investigating the oxide extracted from a Hungarian rutile that it became evident Gregor had discovered a new element. It was Klaproth, the discoverer of uranium, zirconium and cerium, who named the new metal *titanium*, from the mythical Titans, first sons of the earth.

The fundamental chemical reactions on which the present-day titanium metal industry is based were discovered by Dr. M. D. Hunter in 1910, yet it was not until 1948 that these metals became commercially available. At present almost 97% of all titanium is being used by the military. Fabrication of this metal has presented several problems that seemingly create design restrictions. The article on page 146 describes a new technique of finish-forming titanium which bypasses separate stress relief for many parts.

Ptolemy's Formula

Engineers at Lockheed Missiles, Van Nuys, Calif., wanted to speed up the data-conversion unit of their missile-telemetering system. To increase data-conversion speed, tape-playback speeds also had to be increased. Yet when the system was pushed to its limit, a flutter or "wow" resulted. Determining the optimum rate developed into an analysis of variations in flutter involving a high order of mathematics.

Mathematicians worked up some preliminary equations which attempted to describe and forecast these variations. In going over the equations, one mathematician noticed that they assumed a pattern he had encountered somewhere in his past reading. He recalled problems first resolved by Islamic astrono-

(*Continued on page 7*)

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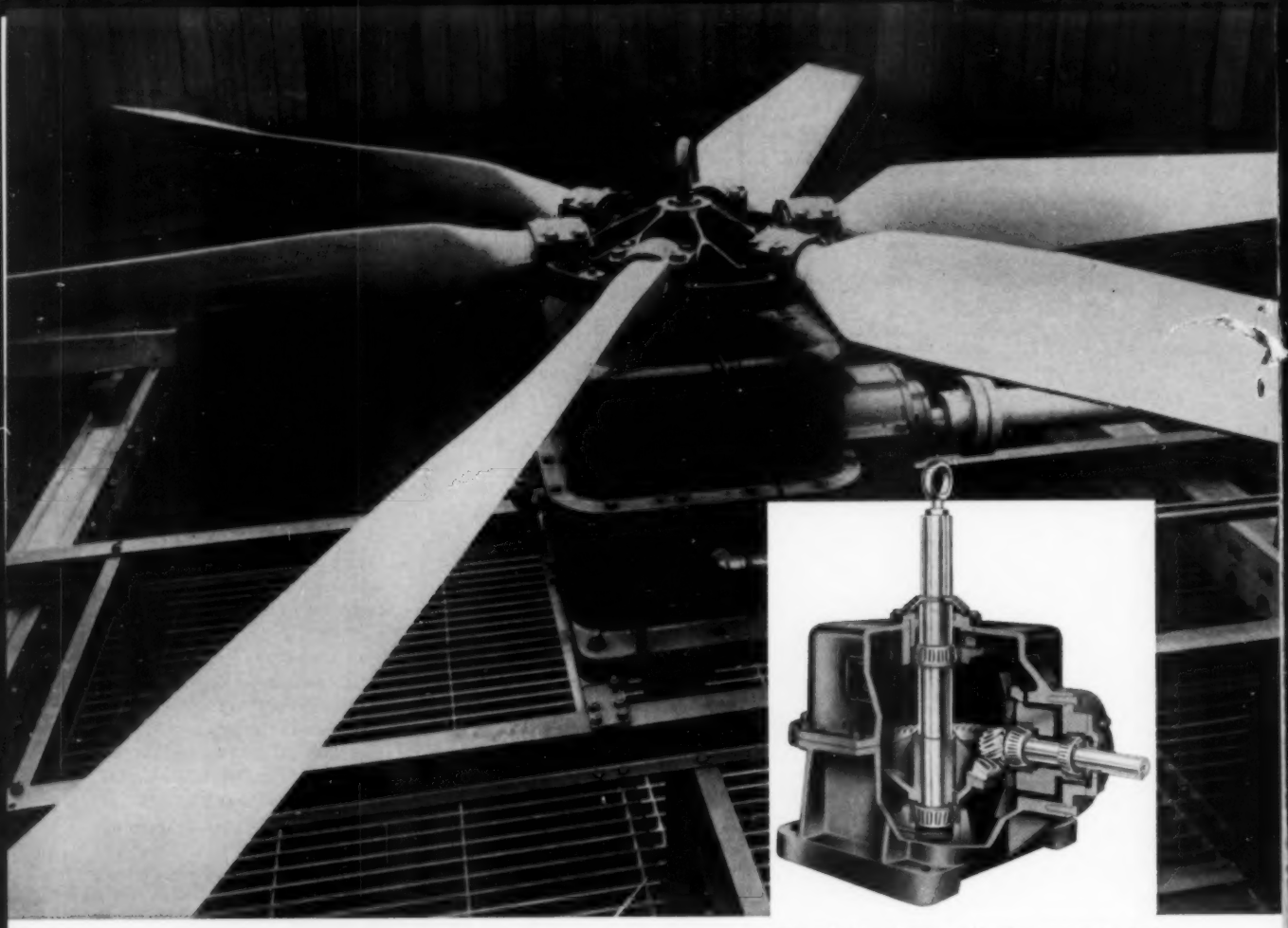


This spiral bevel gear combination permits the flexibility required to meet rugged 24-hour service while providing an economical, self-contained unit which requires practically no maintenance.

How to obtain help when you design bevel gear assemblies

The men who designed the gear reducer for the cooling tower fan shown above were assisted in many ways by Gleason engineers.

Cooling tower fan operation is generally recognized to be one of the most severe tests to which a gear reducer can be subjected. These towers demand a gear system that can operate twenty-four hours a day, three hundred and sixty-five days a year if necessary.

The gear reducer is subject to heavy loads and lies in the path of moist, corrosive air streams.

The gear drives for these cooling tower fans are subject to heavy loads and lie directly in path of moist, corrosive air streams.

Here is what the customer and Gleason engineers developed.

A spiral bevel drive of 19 x 76 combination and 2.5 DP. With spiral bevel gears the tooth bearing is localized which assures smooth and quiet operation and permits some mounting deflections without concentrating the load dangerously near either end of the tooth.

The use of this gear design also allowed the flexibility required to fit the fan unit into the over-all design of the tower and to produce an economical, self-contained unit which requires little or no maintenance.

Next, our engineers produced and tested prototypes of the design which the customer in turn tested in the final product.

Our engineers can also help you select proper mountings for such gear assemblies and advise you on such details as lubrication.

If you would like to take advantage of this service, write us the next time you have a problem involving bevel or hypoid gear systems. Furnish data covering type of application, loads and speeds and prints of the mountings. We would be pleased to assist you in the selection of your gears.

Meanwhile, you may find these Gleason Technical Handbooks helpful in your work:

"20° Straight Bevel Gear System"
"Spiral Bevel Gear System"
"ZEROL Bevel Gear System"

GLEASON WORKS

Builders of bevel gear machinery for over 90 years

1000 UNIVERSITY AVE., ROCHESTER 3, N. Y.

Interesting to Note . . . .

mers in the Middle Ages. They were puzzled by the occasional capricious departure of planets from their orbits, so they worked out a formula which predicted these deviations, although it didn't explain them. It was felt by the Lockheed group that the variations of these two differing phenomena could be expressed by the same formula.

Research showed that early astronomers used a table of chords (developed by Ptolemy in the first century) as one of their measuring devices. The Islamic equation, when applied to a problem of the Twentieth Century, proved successful and enabled the group to process data more swiftly, while retaining accuracy.

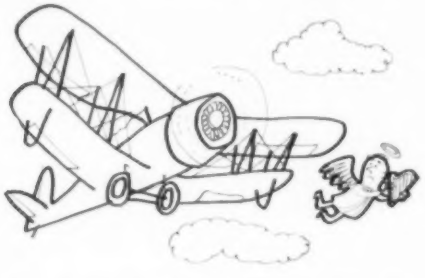
A bibliography of mathematical functions, which reviews the most useful, appears on page 183.

A Place in the Sky

"Everything that can be invented, has been invented." So said a Bishop of the United Brethren in Christ Church before a Mid-western Bible class less than 75 years ago. "Judgment day is closer than we realize, for since there is nothing more to invent, progress must give way to that great day of Justice."

"But sir," said a voice from the audience, "don't you thank man will ever conquer the skies?"

"Conquer the skies?" replied the preacher, "this would be sacrilege. Only the angels may inhabit the heavens. Man has and will probably continue to reach



the realm of the Almighty, but his foolish efforts will be doomed to failure."

It is not unusual that views of this sort were held during the past century, but it is ironical that while Bishop Milton Wright was preaching to his parish in Dayton, Ohio, his two sons were busy assembling in their bicycle shop a machine which would soon give man a place in the sky.

What was an idea a century ago has become a bellwether of our present economy. The aircraft industry has not only contributed to the security and economy of the nation, but has resolved design problems which benefit other industries as well. Two milling machines which are controlled by an electronic tracing system are an example of this and are discussed on page 150.

The Clear Thin Line

The advent of Edison's incandescent light brought about many problems—including complete panic on the floor of the London Stock Exchange. However, it also led to the discovery of the electron rectifier.

Edison examined some 6000 variations of vegetable fibers in search for the right filament for his lamp bulb. He noticed that all the filaments would cause the inside of the bulb to blacken. The deposit of this carbon dust on the bulb was uniform, save for a clear, thin line on one side near the filament support. It wasn't until the discovery of the electron by J. J. Thompson, in 1896, that Ambrose Fleming, Edison's assistant, was able to understand the phenomenon of the thin clear line.

When heated, the incandescent carbon filament ejected electrons, which traveled outward to the glass bulb. Some of these electrons were obstructed by the metal supporting the filament, hence the clear line. Fleming tried a variation of Edison's apparatus by surrounding an incandescent filament with a positively charged metal wall. This permitted the passage of the positive half of every cycle of alternating current and became the first electron rectifier.

Some of the electronic equipment discussed in the article on page 164 is a direct result of the work of both Edison and Fleming.

The Legend of the Monk

In the city of Caen, land of France, lived a monk named St. Feutre. Feeling the necessity of making a pilgrimage to the shrine of St. Michel-in-Peril-of-the-Sea, he set forth for the village of Pontorsan with his staff, his cloth and a new pair of sandals.

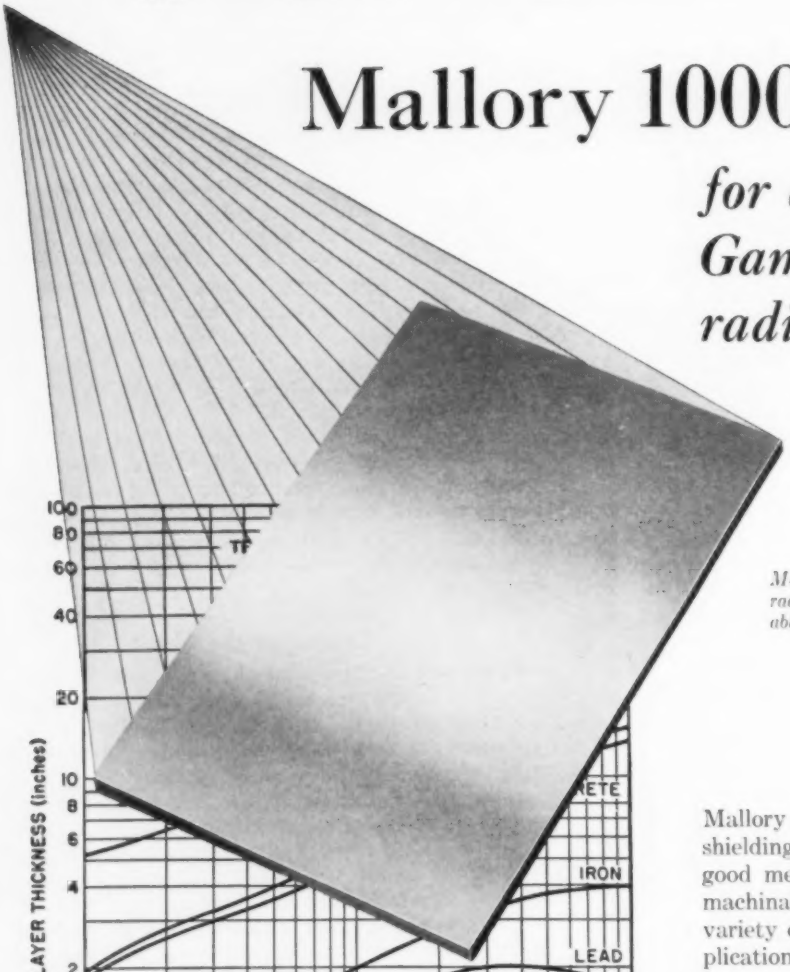
Now, as the journey was a long one, and as the new sandals were causing much discomfort, the holy man could only feel that his painful steps were penance for his sins. At times, as the way waxed long, the monk felt that his penance was more than he could bear. It would be so easy to pluck some wool from the backs of passing sheep, put it in his sandals and thus ease the soreness. Trusting that such an action would not displease God, the monk grabbed several handfuls of the wool, which when placed within his shoes, provided great comfort. On the fifteenth day, he arrived at the island of Mont St. Michel, and as he stood before the shrine of St. Aubert, he became aware of a miracle which had fallen upon him. For as he removed his sandals, he noticed that in the bottom of each was a new cloth, firm of texture, soft to the touch, and strong, made from the wool of sheep, tramped down by his daily footsteps.

This legend, which has prompted the American Felt

Co. to adopt the sandaled foot as its trademark, shows that the use of felt dates back many centuries. Current trends are towards felts made from synthetic fibers. An article discussing design features of these synthetic felts appears on page 178.

Mallory 1000 Metal

for effective Gamma radiation shielding



Gamma absorption characteristics.

Mallory 1000 "slab" for radiation shielding available in sizes up to 6" x 15".

Mallory 1000 Metal is ideal for radiation shielding applications. It has high density, good mechanical strength, and excellent machinability . . . is available in a wide variety of shapes and sizes for many applications in this field.

Mallory 1000 Metal is already being used in numerous applications such as shielding isotope shipping containers, cobalt teletherapy machines, and oil well logging equipment.

Mallory 1000 Metal effectively absorbs Gamma radiation . . . low intensity neutron bombardment causes only moderate activity.

If you have radiation shielding problems, it may pay you to investigate Mallory 1000. Write for your copy of Technical Bulletin 6-7C.

Expect more . . . get more from

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Developments

To Watch

TRANSISTOR WITH 40 AMP SWITCHING CURRENT CAPACITY . . .

. . . is still in the experimental stage at the Div. of Radiophysics of the Commonwealth Scientific and Industrial Research Organization (CSIRO), Sydney, Australia. This current is substantially higher than that handled by transistors developed to date. Characteristics of the new transistor, according to its developers, Drs. Bowen and Fletcher of CSIRO, are: max collector current, 40 amp; max collector-base voltage,—30 volts; current gain (Ic/Ib) at 40 amp, 10-15; rise time (grounded base) 1 μ sec; extrinsic base resistance, 1 ohm; max total average dissipation, 5 watts; peak pulse output power 1 kw. An alloyed junction PNP transistor with annular emitter base geometry, it has an indium-gallium alloy emitter. In its experimental stage, the transistor is designed to produce 1 kw pulses of a few microseconds duration for use in radar-type modulators.

FOUR MAJOR METALS IN THE FUTURE AUTOMOTIVE INDUSTRY . . .

. . . will be iron, aluminum, magnesium and titanium—plus silicon for major construction work, according to Dr. Andrew A. Kucher, vice pres. of engineering and research of the Ford Motor Co. The other elements he said are becoming scarcer, and therefore too costly for use even as alloy agents. The present cost of titanium is likely to change in the near future to where it may easily compete with stainless steel. Still looking ahead, Dr. Kucher said that ceramics and ceramic metal compounds capable of sustaining rapid temperature changes will be commonplace. Metals in general will be produced to realize a bigger fraction of their theoretical strength. For example, from 100,000 psi today to 1 million psi in the near future, materials will be more easily compounded, and new furnaces with temperatures in excess of 10 million degrees will be available.

MEASURING THE ADHESION OF ORGANIC COATINGS . . .

. . . to metal surfaces without at the same time measuring their mechanical properties with a technique developed by the Paints Div. of Imperial Chemical Industries, Ltd., Wexham Rd., Slough, Buckinghamshire, England. The method does not require that the specimen being tested be in a vacuum. Basically, it consists of decelerating the specimen of coated metal being tested in such a way that strong forces are created which cause the coating to fly off the metal surface. This deceleration is accomplished by firing a bullet, in the form of a thin steel disk carrying a coated spot, at a specially designed steel target which has a hole at the place where the coated portion of the bullet hits it. The last bullet is thus rapidly decelerated and stopped by the steel plate, although the particular coated portion of the bullet does not itself come into contact with the target.

PRESSURE OR STRAIN CAUSES ELECTRICAL RESISTIVITY CHANGE . . .

. . . in a hard elastic material, used in pressure sensing devices for measuring weights, forces, vibrations, fluid pressures. The basic cells are made from intermetallic resins, processed by the zirconium tetrachloride method, and then heat treated. The cells may be made with almost any final resistance, depending upon the heat

(*Continued on page* 10)

treating used in its manufacture. Compressive strength varies up to 25,000 psi for high pressure cells. Minimum area of load application is 0.001 mm, while cells one foot square have been made. The greatest load cell ever designed has a shock rating of 250,000 psi, while the smallest is 0.003 gram with a resistance change of 10,000 ohms over the force differential of 0.003 gram. Frequency response is 60 cps for most types, but can be increased to 400 cps. Within 5% linear over the rated force range. The material was first developed for use as a strain gage. Cells have less than ½ of one per cent variation up to 300 F; high temperature cells up to 1650 F. As made by the Clark Electronic Laboratories, Box 165, Palm Springs, Calif., the devices are sensitive on one side only, or on 2, 3 or 4 sides. Two or more sensitive areas on one side are available.

A THIN LAYER OF TITANIUM CARBIDE ON STEEL . . .

. . . is possible with a procedure developed by Metallgesellschaft AG, Frankfurt, Germany. The procedure involves an improvement on an older method which used the reaction of titanium tetrachloride with hydrogen and a hydrocarbon at 1800 to 2550 F to obtain titanium carbide and hydrochloric acid besides another hydrocarbon. Compared with the old method, Metallgesellschaft uses a lower temperature of 1750 F, which is necessary to allow the vapor plating of steel products without loss of the steel properties. A second improvement is the prevention of the formation of free carbon. The resulting titanium carbide layers of about 20 microns are very smooth and can be polished with diamond powder to a high brilliancy. Data has been collected for titanium carbide plated drawing dies and mandrels used for tube and wire drawing. These tools are reported to be superior to those plated with hard chromium, but cost the same. Thread guides plated with titanium carbide for the production of fibers have shown much better abrasion resistance without electrostatic loading compared with steel alloys and ceramic materials.

COATING BALL AND ROLLER BEARINGS . . .

. . . in an effort to improve their resistance to wear caused by slip is being investigated by the Metallgesellschaft AG in Frankfurt, Germany. Effective protection against this type of wear has been obtained by coating the surfaces of the bearings with nitride, boride, or silicide of titanium. This type of coating also has been found to be successful with other materials, such as bronzes. According to the reports, these coatings have good resistance to shock stresses, and can be applied to both the races and balls and roller cages as well as the balls and rollers. Titanium nitride has been found to be particularly effective.

LOW DENSITY EXPANDED POLYSTYRENE . . .

. . . anounced by the Toyad Corp. of Latrobe, Pa., has a density of 1 lb per cu ft. Called Chemfoam KR-1, it has a K factor of less than 0.25, and is recommended for thermal insulation. The material is isotropic and has good weather-resistant properties. When used as a core in a sandwich structure, it has the advantage of being bonded to the skin materials in the molding process. Skins may be of plywood, aluminum, steel, or plastic sheets.

POWDERED METAL FILTERS . . .

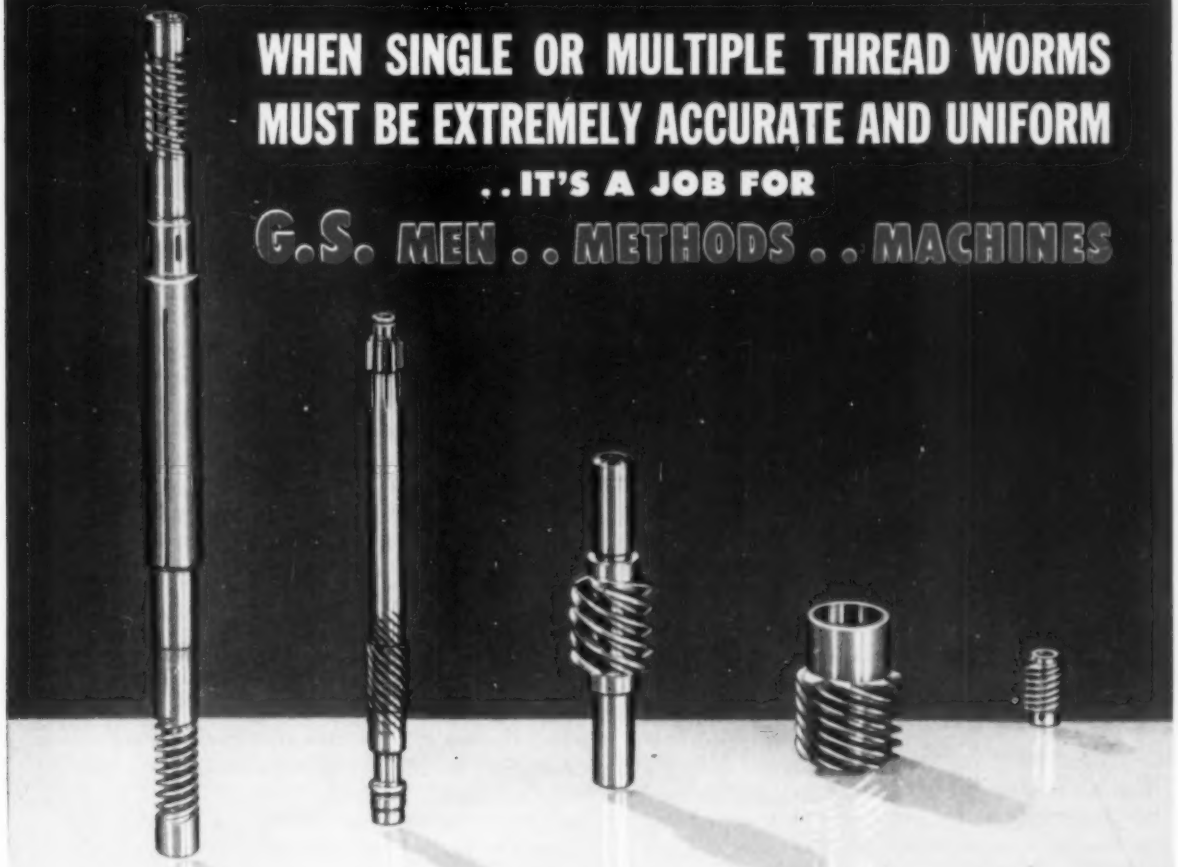
. . . of nickel and Inconel powders are pressed and sintered into porous shapes for filtration of high temperature gases or liquid. Soon to be announced by the Cuno Engineering Corp., Meridan, Conn., is a filter made of Monel metal powder which is

(Continued on page 12)

WHEN SINGLE OR MULTIPLE THREAD WORMS MUST BE EXTREMELY ACCURATE AND UNIFORM

. . IT'S A JOB FOR

G.S. MEN . . METHODS . . MACHINES



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Top precision in the G. S. 5 and 8 thread hardened and ground Worms pictured above, is consistently maintained on G. S. precision equipment. Accuracy and uniformity of lead, and thread spacing accuracy, of vital importance in precision multiple Worms, is under the strict control of highly skilled workmen. The 4 thread Worm has hobbed threads, case hardened and polished. This method is more economical and a great degree of accuracy is maintained through G. S. specialized heat treating. The 3 thread Worm is hobbed and brushed. This most economical method is recommended for *unhardened* multiple thread Worms. The single thread Worm is precision ground from the solid, on a heat treated shaft. ★ G. S. men, methods and machines are developed to produce a degree of accuracy, efficiency and economy that will cut costs and improve product performance for you. Modern equipment and extensive inspection facilities assure absolute control of quality. Customer furnished blanks or a complete job, optional. Send drawings or details, today.

41 Years of Specializing in Small Gearing!

expected to find use in the reprocessing of nuclear reactor fuel elements. No upper operating temperature has been set for the Monel filter, but for Inconel it is 1300 F and nickel 700 F. Control of particle size and processing conditions results in pores of uniform size. Standard filters are available with particle retention capacity of from 5 to 40 microns. The filter cartridges are 2¾ in. in dia and 9¾ in. long. A series of these can be welded together to get added length. Wall thickness is ⅛ in.

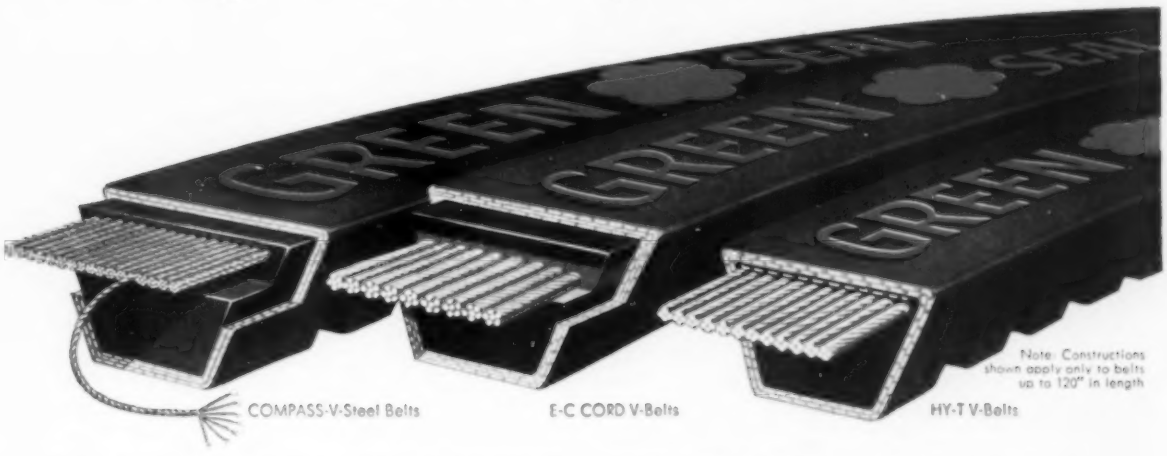
DIESEL ENGINE WITH 50% THERMAL EFFICIENCY . . .

. . . has been designed at Stevens Institute of Technology, Hoboken, N. J. The single-cylinder Rieseler engine, which has not been built, is a continuation of the work that was started in Germany some 20 years ago by a Herr Rieseler, a naval engineer, and Prof. Kamm, of the Technische Hochschule in Stuttgart. After the war Prof. Kamm brought the engine design to the attention of the U.S. Army, and the work at Stevens Tech was sponsored by the Detroit Arsenal. The Army is interested in a 4-cylinder engine for tank and truck use. The multi-cylinder design is in the layout stage. The 50% efficiency figure is based on the data from the German tests, and calculations from the new Stevens design which incorporates a special combustion chamber. Said to be the heart of the engine, it leans to a concept of a pre-combustion chamber, accomplishing a slow mixing of the air and fuel to give a slower burning rate. The peak MEP is 437 psi, which is about twice that of the average diesel engine. The supercharger operates at 4 atmospheres—3½ atm in the cylinder and ½ atm used for scavenging. According to Mr. Kamm (son of one of the designers) at Stevens, an engine of this design will: have greater hp per installed volume (for equal hp it will be ⅓ the size of conventional engines); reduce vehicle weight; and reduce fuel consumption by 10%. It will operate at 3600 rpm and will be made of aluminum wherever possible.

AND IN ADDITION . . .

. . . Unions were defeated in a recent election to determine whether the Engineers and Scientists of America (ESA) or the United Auto Workers would represent engineers at the Minneapolis plant of the Minneapolis-Honeywell Regulator Co. The results were 896 for "no union"; 304 for the UAW; and 197 for the ESA. Technicians at the plant also turned down unionization. Previous to this action, the union members, who belonged to The Engineers and Scientists of America, voted to change their affiliation to the AFL-CIO. Anti-union engineers, and company management then demanded an NLRB supervised election which resulted in the "no union" vote. . . . A rear-view automobile mirror has a built-in photocell which measures the light being reflected into the driver's eyes, as a result of the headlights of the following car, and automatically flips the mirror into the "dim" position. The driver can adjust the point at which the mirror switches to the dim position. Manufacturer is Instrument Research Co., 22 Anselm Terrace, Brighton 35, Mass. Approximate cost: $28.50. . . . The foreign car is making its presence felt in this country, with England announcing that sales of British automobiles shows an increase of 160% in the first quarter of 1957 compared to a like period in 1956. This figure also represents more than 33% of the foreign cars sold in the U. S. . . . Beginning next September, an Engineering Executive Program will be conducted by the University Extension at the University of Calif., Los Angeles. The program is designed to meet the needs of engineers who will fill top executive positions in industry within the next decade. . . . A silicon carbide rectifier has been operated at temperatures up to 1200 F in tests run at the General Electric Research Lab., in Schenectady, N. Y. The same rectifier also has been operated at —100F. . . . A definite delivery date on titanium castings is being quoted by the Oregon Metallurgical Corp., Albany, Oregon. Machined graphite is used for molds, with 50 castings per mold, meeting all specifications. Globe valves are being made.

Now—V-Belts with the Green Seal solve the major multiple drive problem



The Green Seal stands for true dimensional stability in V-belts. And with Green Seal dimensionally stable belts you can be sure that matched sets are truly matched and will stay matched—that mismatching (the biggest problem in belting multiple drives successfully) is a thing of the past.

The key to dimensional stability lies in the tension members of the belt. For many years, steel cables as developed by Goodyear were the only length stable load carriers, but now they have been joined by synthetic cords, thanks to the amazing Triple-Tempered 3-T process.

The 3-T process is an exclusive method of tempering the cord with Tension, Temperature and Time for maximum strength and minimum change in dimensions. This assures no change in length during storage plus greatly increased shock- and stretch-resistance on the drive.

The end result is smoother, longer-running teams of belts that give you maximum, trouble-free, horsepower hours at minimum cost. What better reason for specifying V-belts with the Green Seal?

DIMENSIONALLY STABLE V-BELTS with the GREEN SEAL by

GOODYEAR

THE GREATEST NAME IN RUBBER

The Goodyear Tire & Rubber Company, Industrial Products Division, Dept. 794, Akron 16, Ohio

Please send me more information about how V-Belts with the Green Seal solve the major problem in belting multiple V-belt drives.

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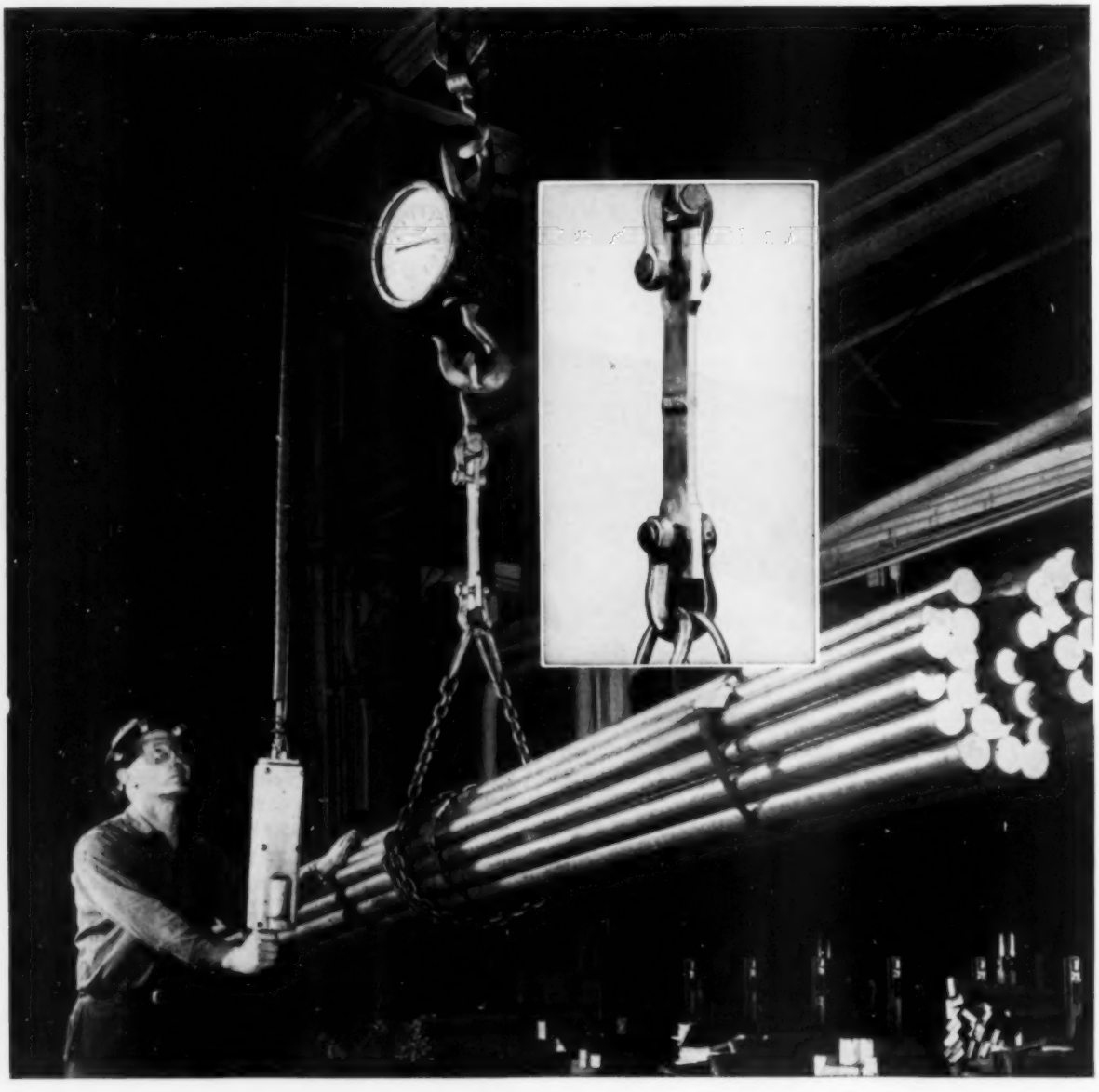
Compass, E-C Cord, Hy-T, Green Seal—T. M.'s The Goodyear Tire & Rubber Company, Akron, Ohio



Weld Strength! Magnesium has 95% weld efficiency

In the picture above, a small arc-welded magnesium bar is supporting a load of four tons. This is one example of what we mean by "strong" when we say magnesium is light but strong. Its weld efficiency, the relationship between the strength of the parent metal and a welded joint, is very high. AZ31B magnesium alloy plate, tensile strength 35,000 psi, has a welded joint tensile strength of 33,000 psi, or a weld efficiency of 95%!

Magnesium can be arc welded, gas welded, or welded by electric resistance (spot, seam or flash). Magnesium plate ½" thick can be joined by arc welding in one pass. It can also be readily joined by most any other method: riveting, bolting, screwing, adhesive bonding and self-fastening devices.

These facts spotlight just one of the many reasons magnesium does a better job in many fabricated metal products. For more information, contact your nearest Dow sales office, or write to us. THE DOW CHEMICAL COMPANY, Magnesium Department, Midland, Michigan, Dept. MA1403H.

YOU CAN DEPEND ON DOW

In heavy-duty drives . . .
demand assurance of

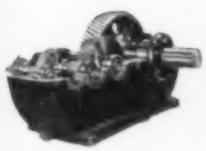
permanent, accurate shaft alignment

Sturdy Housing of heavy, close-grained gray iron provides rigid support of shafts. Designed so that all parts can be removed without disturbing base or draining oil.

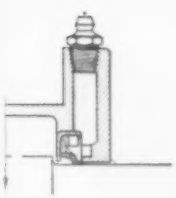
It's yours...with these other "plus" performance features—in LINK-BELT Parallel Shaft Drives

Under the shocks and overloads that are often imposed upon parallel shaft gear drives, rugged housing construction is compulsory if shaft alignment is to be maintained. That's why Link-Belt adds special reinforcement at points of greatest stress . . . has developed this design expressly for endurance in heavy-duty service.

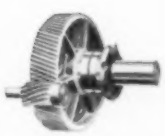
Write for Book 2619 on this broad line with ratios to more than 300:1. Or get first-hand facts from your nearest Link-Belt office.



Ball and Roller Bearings are of ample size and capacity to withstand shock and overloading.



Grease-Lubricated Seals on all input and output shafts prevent entrance of dirt, water.



Precision Gears and Shafts are arranged to provide high reduction ratios in small space.

Automatic Splash Lubrication reliably supplies oil to all gears and bearings.

14,308

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ENCLOSED DRIVES

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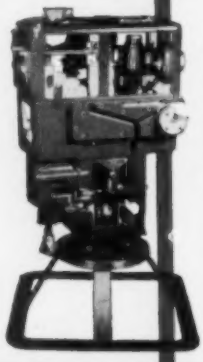
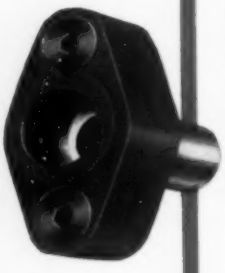
5 practical ways to "streamline"

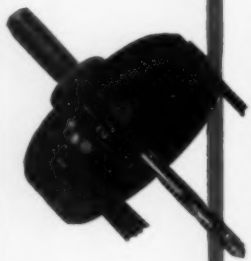
...without sacrificing fastening strength



1. Counterbored holes are the simplest approach to flush surfaces using standard socket cap screws. The advantage of specifying genuine Allen O Head Cap Screws is the greater strength of Allenoy steel... you can use smaller sizes for closer spacing and reduced weight. Call on Allen, too, for *very large* socket-head, precision cap screws — up to 2½ inch diameter.



2. Countersinking enables you to get absolutely smooth external surfaces using Allen O Flat Head Cap Screws. Allen O Cap Screws feature the exclusive Leader Point which makes screw starting easier and guards against thread damage.



3. Button Head Cap Screws produce snag-free unbroken surfaces where countersinking is impractical. Button-head hex sockets are necessarily shallow. In genuine Allen O Button-Head Cap Screws, sockets are cold forged without broaching, in extra strength Allenoy steel... essential protection against stripping the sockets under high torque pressure.

4. A ready made hole tapped in forged steel solves many a design problem. It's called the Allenut. It can be anchored in soft material to assure durable threading, or recessed to permit tightening with an Allen Hex Key.

5. Bright finish, or rust and corrosion resistance call for Allen O Stainless Steel Cap Screws. They are standard stocked items (both NF & NC threads) readily available in a wide range of sizes from Allen Distributors.

YOUR ALLEN DISTRIBUTOR can give you practical help and swift service. For complete information on any technical fastening problem, write our engineering department direct.

ALLEN HEAD

ALLEN

MANUFACTURING COMPANY

Hartford 2, Connecticut, U.S.A.

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And you get a lot of new user-benefits to merchandise . . . direct readings, rather than dials and scales . . . remote indication from plant to office if needed . . . production figures that serve as a fair base for wage and incentive payments, production and stock *Count*rol, tax computation . . . and as proof of your own performance guarantee. So call the V-R man in, *when you begin* . . . look him up in your local phone book, or write direct to:

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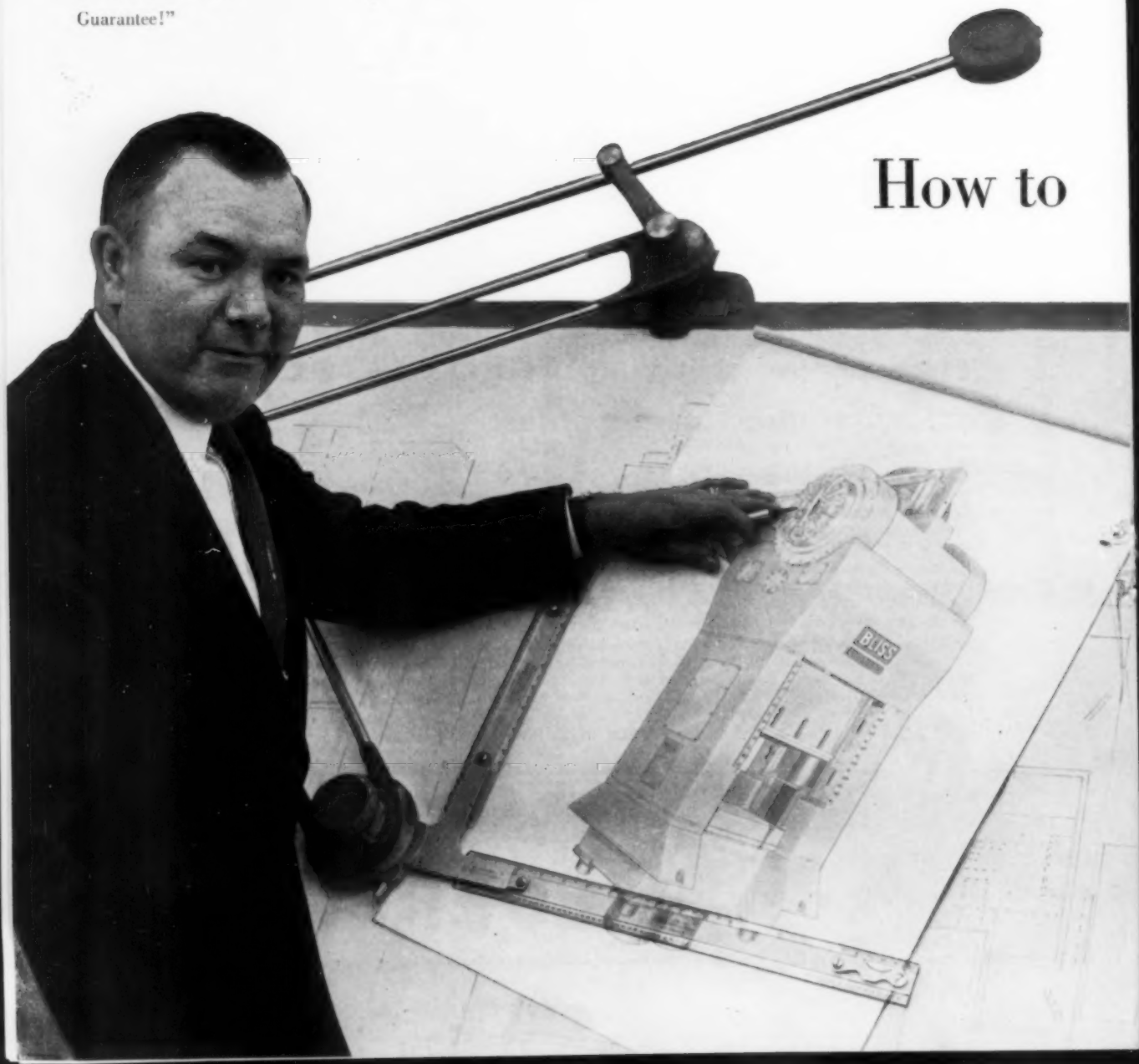
How to



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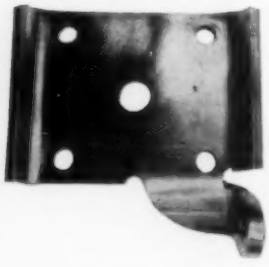
Why this particular rear spring bracket becomes important to all manufacturers

In itself, the ArmaSteel spring bracket described here is of small interest except to the automobile manufacturer for whom we made this study. But this bracket becomes significant as a typical example of what is being done—what can be done—here at Central Foundry Division to increase strength, reduce weight, and reduce the cost of many types of parts by means of relatively new stress analysis testing techniques.

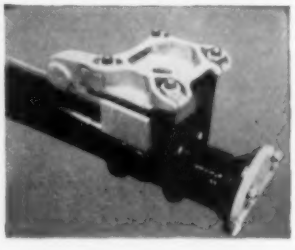


1

The steel stamping for the rear spring bracket (clip pad) of a popular passenger car. ● Made from .438 stock, S.A.E. #1015 steel, the part weighs 4.2 pounds. From this, a casting is to be evolved with these specifications: 800 pounds maximum push or pull load on shock absorber ear, 75 foot-pounds assembly torque load on each U-bolt lock nut.

2

Cast design no. 1 is created. ● Already slightly lighter in weight (4 pounds) than its stamped counterpart, this version is submitted for stress analysis. Preliminary tests indicate this casting is overdesigned. The unnecessary ribs can be eliminated, shock absorber ear can be tapered, and a second, lighter design is evolved, weighing only 3.25 pounds.



3

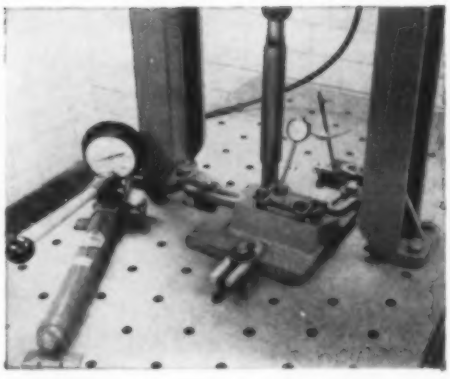
Testing. ● Using a production axle, each casting design is fastened on over rubber pads. The insertion of a steel block duplicates spring thickness. Production U-bolts and lock nuts are also used to duplicate actual loading conditions and torque characteristics.

4

The stress pattern on casting is established. ● Using brittle lacquer, the areas of highest stress concentration are determined so that casting weight can be further reduced without reducing the strength of the part.

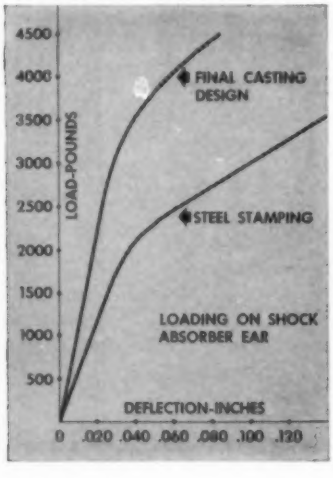
5

The 4th and final design. ● Now weighing but 2.90 pounds, the fourth version is fastened to the test device's loading fixture (shown at right) to test the shock absorber ear for deflection and yield points. This revised version proves the value of stress analysis by sustaining nearly 3,000 pounds load (yield point) at less than 0.30 inches deflection—almost 2,200 pounds ABOVE the auto manufacturer's specifications! *Only* now will the tested design be submitted for approval.



6

Testing shock absorber ear on casting for Deflection and Yield Point. ● The casting was fastened to the loading fixture simulating actual loading conditions using rubber pad and steel block, and load increments were applied on the shock absorber ear.



7

Stress analysis helped create a stronger casting design. ● Above graph illustrates the improved strength and rigidity of the casting over the stamping.

8

Even the actual load on U-bolts was determined. ● Strain gauges, as shown above, were fastened to U-bolts, and strain readings were made at required torque. The bracket, as it finally evolved, assured the auto manufacturer that the final design was without inherent weakness.

Just as we helped this manufacturer to produce a better bracket at lower cost so, too, can our research department assist you by means of the latest equipment and processes including stress-analysis, Cobalt 60, Radiography, Spectrochemical analysis and Sonic testing. Brief descriptions of these and many other phases of modern casting methods are contained in the new book, "SHELL CASTING AT CENTRAL FOUNDRY".

Write for free copy of new "Shell Casting" catalog, today.

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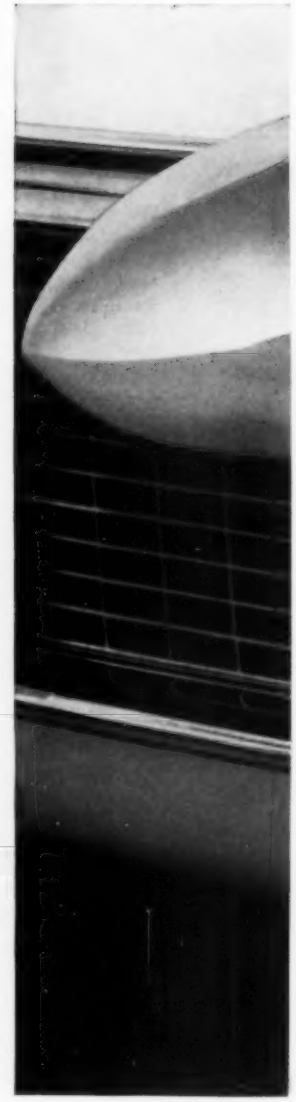
For whatever you fabricate . . .

N-A-X FINEGRAIN STEEL COMBINES STRENGTH WITH FORMABILITY



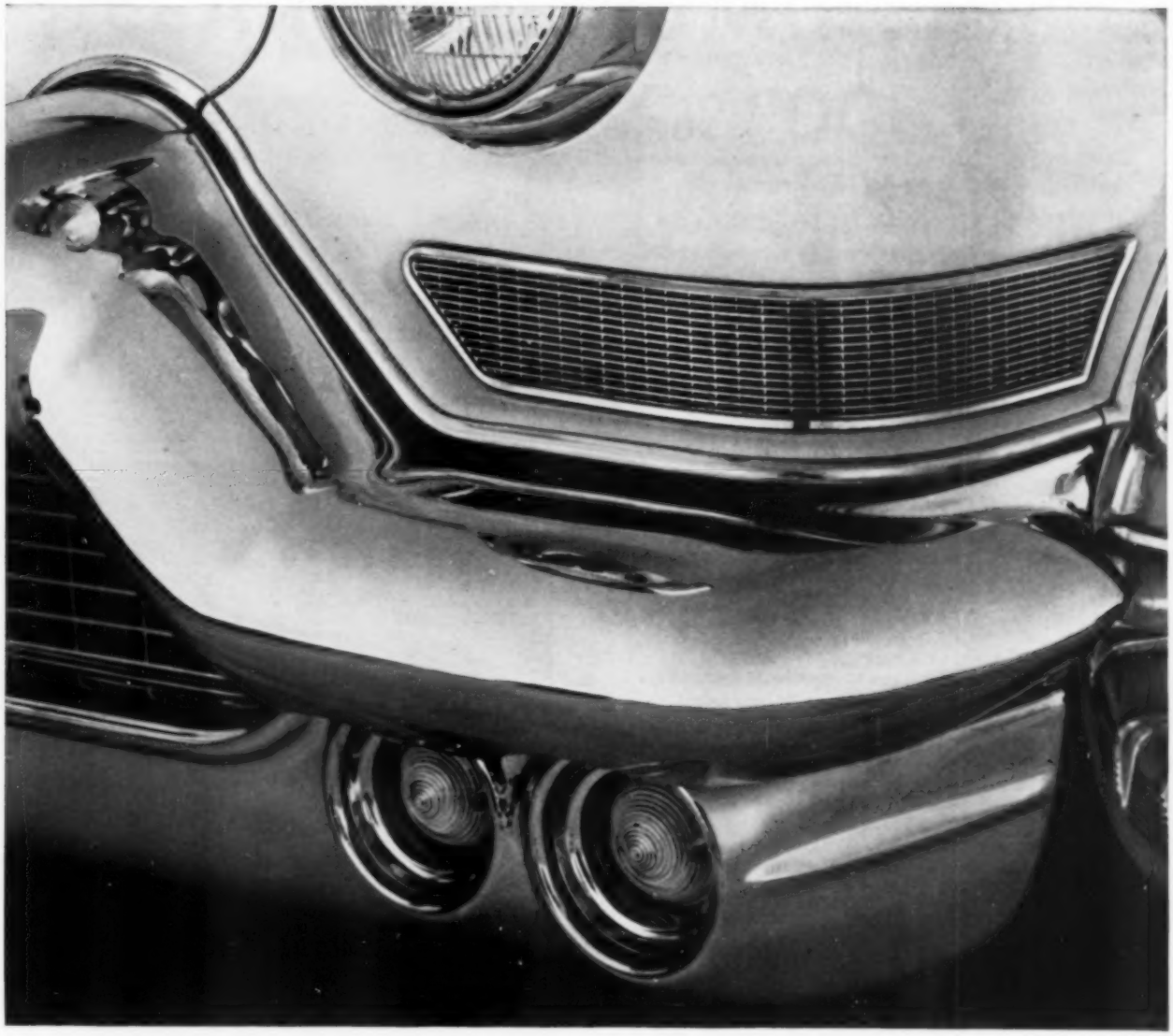
Among the many economical advantages of N-A-X FINEGRAIN—a low-alloy, high-strength steel with widely diversified applications in modern metals design—is its combination of great strength with excellent formability. Even at the higher strength levels (50% greater than mild carbon steel) N-A-X FINEGRAIN can be cold formed and drawn into difficult stampings and cold formed shapes.

Take these qualities and add the ability of N-A-X FINEGRAIN to be readily polished to a high luster at minimum cost, and when plated, you have a steel ideally suited for such applications as bumpers, bumper guards, and many others where strength and toughness with good finish is important.

Engineers and designers like N-A-X FINEGRAIN especially because its physical properties are inherent in the "as rolled" condition. No subsequent treatment is needed to insure its characteristics.

Check these other important advantages: N-A-X FINEGRAIN steel, compared with carbon steel, is 50% stronger • has high fatigue life with great toughness • is stable against aging • has greater resistance to wear and abrasion • is readily welded by any process • offers greater paint adhesion. NOTE: Where greater resistance to atmospheric corrosion is an important factor, our N-A-X HIGH-TENSILE steel is recommended.

For whatever you fabricate, from bumpers to bulldozers, with N-A-X HIGH-STRENGTH steels you can design longer life, or less weight, and economy into your products. Let us show you how.



One of many applications where N-A-X FINEGRAIN'S strength with formability saves production money.

N·A·X
HIGH-STRENGTH STEELS

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☐ Please send me technical data on N-A-X FINEGRAIN steel.
☐ Please have your representative contact me.

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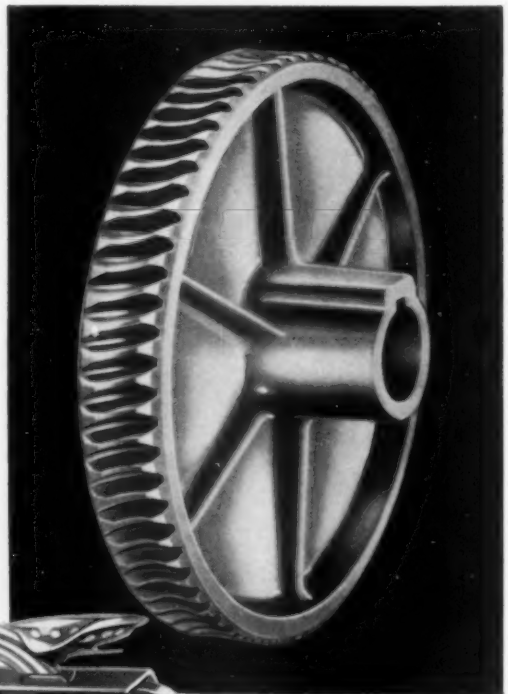
toughness of MUELLER BRASS

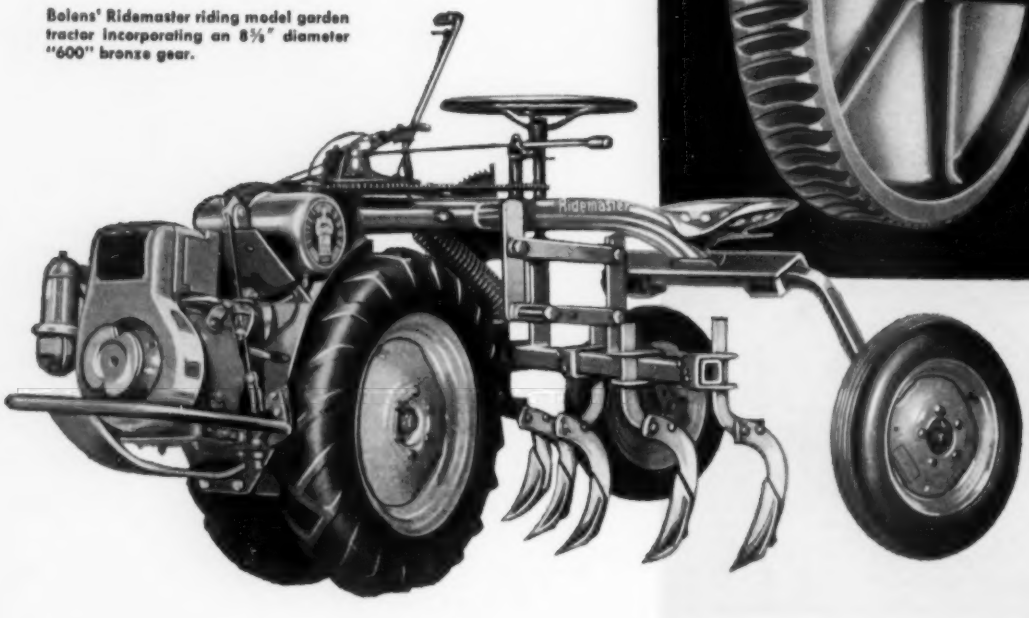
"600" series bronze alloys

Forged bronze gears made from tough, long-wearing Mueller Brass Co. "600" bearing alloy are proving their ability to withstand punishment in the popular outdoor power equipment manufactured by the Bolens Products Division of Food Machinery and Chemical Corporation, Port Washington, Wisconsin. The Junior and Super Mustang rotary tillers, all employ "600" main drive gears to dependably transmit engine power to drive assemblies. The going is rough for equipment of this type in cultivating or tilling heavy soil—but Bolens has a record for ruggedness and, on these and many other Bolens products as well, Mueller Brass Co. "600" gears help make possible that fine performance.

Mueller Brass Co. "600" bearing bronzes are available as forgings, or in rod form. They provide unusually high tensile strength, a dense structure, good resistance to corrosion, and excellent bearing properties. Because of their good machining qualities, the "600" series bronzes can be finished readily—usually at substantial savings in COST.

It will pay you to investigate these alloys for your products . . . why not write today for full information.

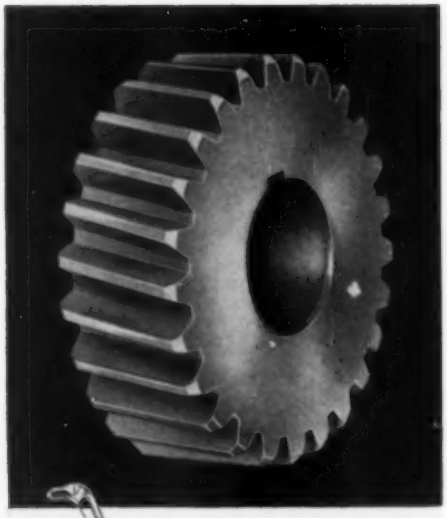




Bolens' Ridemaster riding model garden tractor incorporating an 8⅝" diameter "600" bronze gear.

and TILLERS prove

CO.



Bolens' Super Mustang rotary tiller incorporating a 25-tooth "600" series bronze worm gear.

• WRITE TODAY FOR THE ENGINEERING MANUAL YOU NEED

Mueller Brass Co. Forgings Engineering Manual H-58565 ☐

Tuf Stuf Aluminum Bronze Alloys Engineering Manual H-58563 ☐

"600" Series Bearing Alloys Engineering Manual FM-3000 ☐

Copper Base Alloys in Rod Form Engineering Manual FM-3010 ☐

198

40

MUELLER BRASS CO.

PORT HURON 22, MICHIGAN

METALS AND ALLOYS REVIEW

by FRANK M. LEVY

Vice-President and Director of Research

One of the most interesting things about our 600 series bearing alloys is the great variety of products in which they find application. In the advertisement to the left you can see how the Bolens people put 600 gears to work in their rotary tillers and garden tractors. Those gears are big, take a lot of abuse, and meet the job needs perfectly. We also make a lot of small parts, too, that have been specified because of the many unusual properties of this series of alloys.

One good example that comes to mind is a shaft bushing on a rotary selector switch that we make for an instrument manufacturer. This selector is used for switching sound-powered telephone circuits aboard Naval vessels. One of the most important considerations in the choice of 600 alloy for this bushing was its resistance to abrasive action on and against a rubber "O" ring. The acceptance test required a stainless steel shaft riding in the bushing to rotate "dry" for a minimum of 50,000 cycles consisting of 360° rotation clockwise followed by a 360° rotation counter-clockwise. The "O" ring must still form a watertight seal at the end of the test. Our 602 alloy was the only one of several materials tested that met the specs. That was pretty good evidence in itself of resistance to abrasion, but, in addition, this customer also found that the use of 602 eliminated the headaches they previously had with seizing and galling.

The pounding action caused by the indexing mechanism attached to the shaft used to give them no end of seizing troubles. The chief product engineer is extremely happy about the way our alloy is performing. Mention was also made of the fact that the corrosion resistance of 602 was mighty impressive. In this application, the alloy passed the 200-hour Navy salt spray test with flying colors.

So, big or small, it seems that there is no end of applications for 600 series alloys. We even have parts working in a machine that slices frankfurters as well as gears in fishing reels. So, it seems that 600 runs the gamut from "red hots to reels". Well, it looks like the end of the page is here again, so I'll close for now. However, if you have any problems or questions about non-ferrous alloys or you're having trouble getting desired performance from a part, why not drop me a line here in Port Huron, and possibly I can be of some service. Send a part print along if you like, and we'll be glad to make proper recommendations.

Thanks again for your time.

Designing with BAKELITE Plastics
BRAND

- ***Two phenolics dress up one product***
- ***Basic material for printed circuits***
- ***Simplified production for complex details***

Often your designs will call for performance properties and production techniques that only plastics can supply. That is the time to evaluate the materials produced by Bakelite Company. Their variety and versatility, besides solving many design problems, frequently are keys to design improvement.

The three examples on these pages employ, altogether, five different BAKELITE Brand Plastics and three fabrication techniques. They merely indicate the range of possibilities in the products made by Bakelite Company—the greatest variety of plastics and resins at one source. You can work with vinyls, epoxies, styrenes, phenolics, polyesters, silicones, polyethylenes, and impact styrenes. And you can call on the unsurpassed resources of Bakelite Company in applying them to your product.

1 General-purpose and chemical-resistant phenolics both serve the SUNBEAM "Coffee Master"

In designing this utensil's handles and base, the chief considerations were good appearance and resistance to heat. BAKELITE Brand Phenolic BMG-5000 met both requirements at low cost. It demonstrates low thermal conductivity* even though it is a general-purpose material. It molds to a superb finish, without warpage or blisters.

The upper section of the "Coffee Master" is rimmed with a ring molded from BMG-2095. This is a chemical-resistant phenolic, since the part has to withstand contact with coffee grounds and hot fumes.

Bakelite Company produces three other classes of phenolics—heat-resistant, impact resistant, and electrical insulating types. For a complete description of all these products, write Dept. XV-145, requesting a copy of BAKELITE Molding News 24.

*Heat distortion temp. 330 deg. F. (D648-45T) (½ in.—264 psi)

2 Phenolic-paper lamination —first step in printed circuit construction

Miniaturization, sturdier construction, and fast assembly are among the advantages of printing electronic circuits on a laminated base. BAKELITE Brand Phenolic laminating varnishes, used in bonding the paper stock that forms the base, have kept pace with developments. In the MOTOROLA "Ranger" plated circuit for example, the lamination has to provide

A good base for bonding the copper . . .
High insulation resistance and low dielectric loss . . .
Translucent construction for checking circuit alignment from opposite sides . . .
Resistance to dip-soldering heat of 500 deg. F.

This particular circuit is made with a "hot punch" laminating varnish. Bakelite Company makes "cold punch" resins as well. If you are working with printed circuits, make sure that the base is fabricated with the resin varnish formulated to fit your need best. Technical information on Bakelite Company products can be obtained by writing Dept. XW-145.

3 Rigid vinyl sheets accurately reproduce designs as intricate as this

The realistic details of this three-dimensional relief map illustrates some of the design advantages of BAKELITE Brand Rigid Vinyl Sheets. Printed flat, the sheets are then softened by heat and shaped by vacuum-forming. Their dimensional stability helps keep printing in perfect register. Because production is fast and simple, costs are low. The map is durable and practical: *it weighs only a fraction as much as the usual 3-dimensional maps, and wipes clean in an instant.*

BAKELITE Brand Rigid Vinyl Sheets are available in a range of widths and thicknesses, clear transparent and colored translucent or opaque. Keep them in mind for dial faces, small parts, packages, fittings, and similar items that require accuracy, low cost, fast production. In service, these tough sheets will resist many chemicals, oils, moisture, and aging, and they can take a lot of handling. For further information, write Dept. XY-145.

There's more to design with in **BAKELITE** BRAND **PLASTICS**

PHENOLICS • STYRENES • VINYLS • IMPACT STYRENES
POLYETHYLENES • POLYESTERS • EPOXIES • SILICONES

UNION CARBIDE

BAKELITE COMPANY, *Division of Union Carbide Corporation* UCC
30 E. 42nd St., New York 17, N.Y. The terms BAKELITE, UNION CARBIDE and the Trefoil Symbol are registered trade-marks of UCC.

STAINLESS STEEL

1/2" O.D. TO

HEAT EXCHANGER, CONDENSER AND EVAPORATOR—Full Range of Sizes

PIPING—Complete Range of Schedules. 40, 10 and 5 Sizes

SANITARY—O.D. and I.D. Polished—For Dairy and Food Processing

HEAT RESISTANT—Special Analyses 309, 309S, 310, 330

BEVERAGE—Cut Lengths or 50' Coils

World's Largest Producer of

SPECIALTY WELDED TUBING

Offers Your Most Complete Source of Supply

You can find a tube to fit any requirement in Republic's full quality line of welded steel tubing.

Manufactured at the Steel and Tubes Division, Republic Tubing is welded by the ELECTRUNITE Process . . . a Continuous Electric Weld method that unites the wall under pressure without the addition of foreign or extra metal. Among other advantages this process assures uniformity of wall thickness, strength, ductility, concentricity, diameter and physical and mechanical properties.

Republic, the pioneer in this improved welding technique, is proud of its many "firsts" in the industry. In addition to introducing ELECTRUNITE® Boiler Tubes to the trade more than 25 years ago —plus Electrical Metallic Tubing and Dekoron®-Coated E.M.T. to the electrical industry, Republic was the first to provide a non-destructive electronic production method of testing tubing used for critical pressure applications, known to the trade as FARROWTEST®.

With plants in four locations, we are able to service you promptly with these complete ranges of analyses of carbon and stainless steels for mechanical, structural and pressure uses. A wide selection of sizes for every tube is also available. (See captions.)

Next time you need tubing or electrical raceways, whatever the application, call your nearest Steel and Tube Representative. Or contact us direct. We've solved a lot of problems in 50 years, and we'll be happy to tackle yours. To get descriptive literature, mail coupon at right.

REPUBLIC

REPUBLIC STEEL

World's Widest Range of Standard Steels

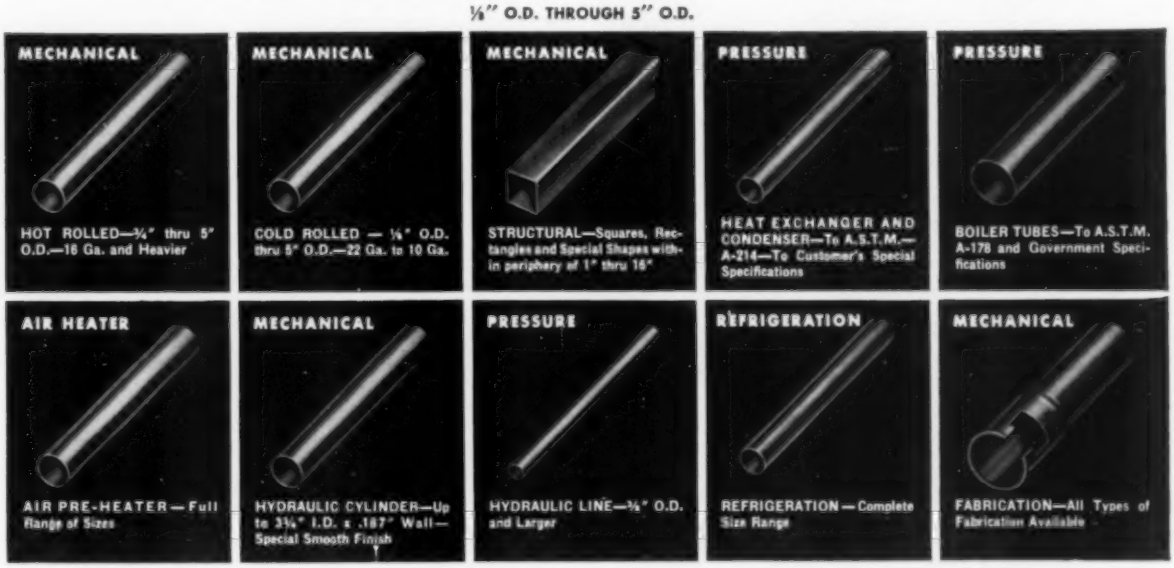
TUBING AND PIPE

40" O.D.

PRESSURE
AIRCRAFT—Exhaust Stacks, Hydraulic Lines and Duct Tubing
PRESSURE
SPECIAL BRIGHT ANNEALED—Up to 4" O.D.—Special Shiny Surface
MECHANICAL
FULL FINISHED—Annealed and Tested for All Mechanical Uses—All 300 Series Analyses
MECHANICAL
ORNAMENTAL—Type 302—Not Annealed—Not Pressure Tested
MECHANICAL
STAINLESS CLAD—Double Wall—Outside Stainless—Inside Carbon

CARBON STEEL TUBING

⅛" O.D. THROUGH 5" O.D.


MECHANICAL
HOT ROLLED—¾" thru 5" O.D.—16 Ga. and Heavier
MECHANICAL
COLD ROLLED—⅛" O.D. thru 8" O.D.—22 Ga. to 10 Ga.
MECHANICAL
STRUCTURAL—Squares, Rectangles and Special Shapes within periphery of 1" thru 16"
PRESSURE
HEAT EXCHANGER AND CONDENSER—To A.S.T.M.—A-214—To Customer's Special Specifications
PRESSURE
BOILER TUBES—To A.S.T.M. A-178 and Government Specifications
AIR HEATER
AIR PRE-HEATER—Full Range of Sizes
MECHANICAL
HYDRAULIC CYLINDER—Up to 3¼" I.D. x .187" Wall—Special Smooth Finish
PRESSURE
HYDRAULIC LINE—⅛" O.D. and Larger
REFRIGERATION
REFRIGERATION—Complete Size Range
MECHANICAL
FABRICATION—All Types of Fabrication Available

ELECTRICAL RACEWAYS

E.M.T. ¾" THROUGH 2"—RIGID STEEL CONDUIT ½" THROUGH 6"

E.M.T.—¾" thru 2"—Inch-Marked® & Guide-Lined, Inside Knurled in Popular Sizes
RIGID STEEL CONDUIT—ENAMEL!TE® —½" thru 6"
RIGID STEEL CONDUIT—GALVITE®—½" thru 6"
DEKORON®-COATED E.M.T. A Plastic Armored Electrical Raceway—½" thru 2"
DEKORON-COATED RIGID STEEL CONDUIT—Plastic Armored Conduit—½" thru 6"

STEEL

and Steel Products

REPUBLIC STEEL CORPORATION
STEEL AND TUBES DIVISION
Dept. C-2370
222 East 131st Street, Cleveland 8, Ohio

Please send me information on:

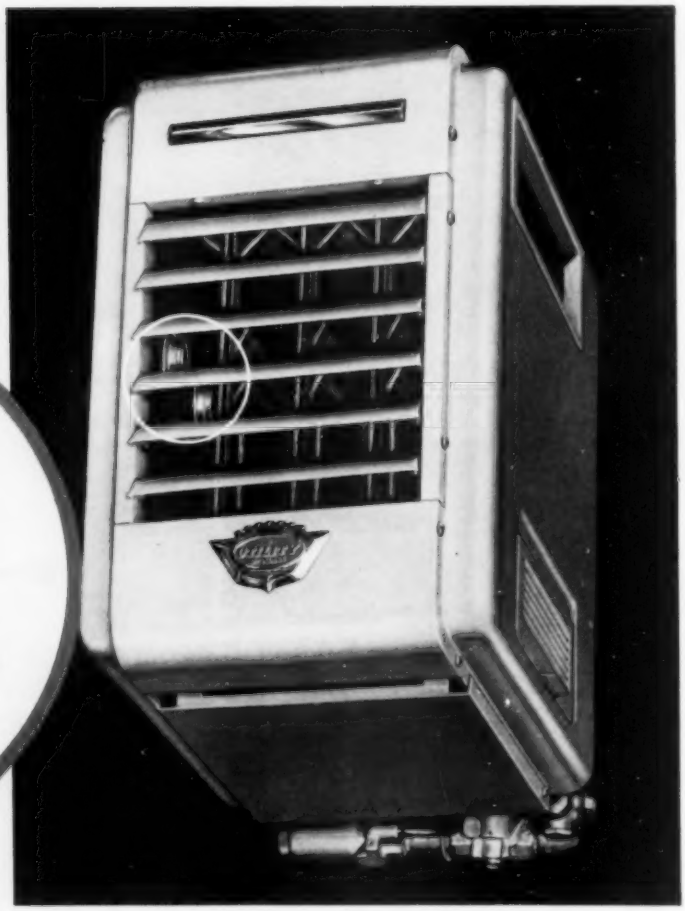
- ☐ Stainless Steel Tubing and Pipe — Type_____.
- ☐ Carbon Steel Tubing — Type_____.
- Electrical Raceways — ☐ Electrical Metallic Tubing
  ☐ Rigid Steel Conduit
  ☐ Dekoron-Coated E.M.T.

Name_____ Title_____

Company_____

Address_____

City_____ Zone____ State_____



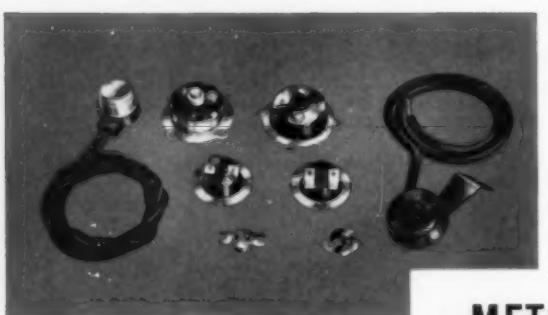
"KLIXON Snap-Acting Controls Satisfy our exacting Requirements" . . . Says Utility Appliance Corp.

"Our gas-fired unit heaters require controls which are compact, accurate and dependable. We have specified Klixon fan and limit controls for many years because they satisfy all of these exacting requirements."

That's how Richard E. Albert, Senior Product Engineer at Utility Appliance Corporation, feels about the use of Klixon Fixed Temperature Controls in his company's famous unit heaters.

Utility Appliance Corporation is one more company on the long list of heating equipment manufacturers who continually specify and use Klixon Controls.

Klixon Fixed Temperature Controls are available in many hermetically sealed and open types in a wide variety of operating temperature ranges. Klixon engineers, specialists in temperature control applications, can help you work out your specific application details. Write for THSN Catalog Sheets.



Typical KLIXON Fixed Temperature Controls used in many applications, including examples of the new 202 series for home appliances.

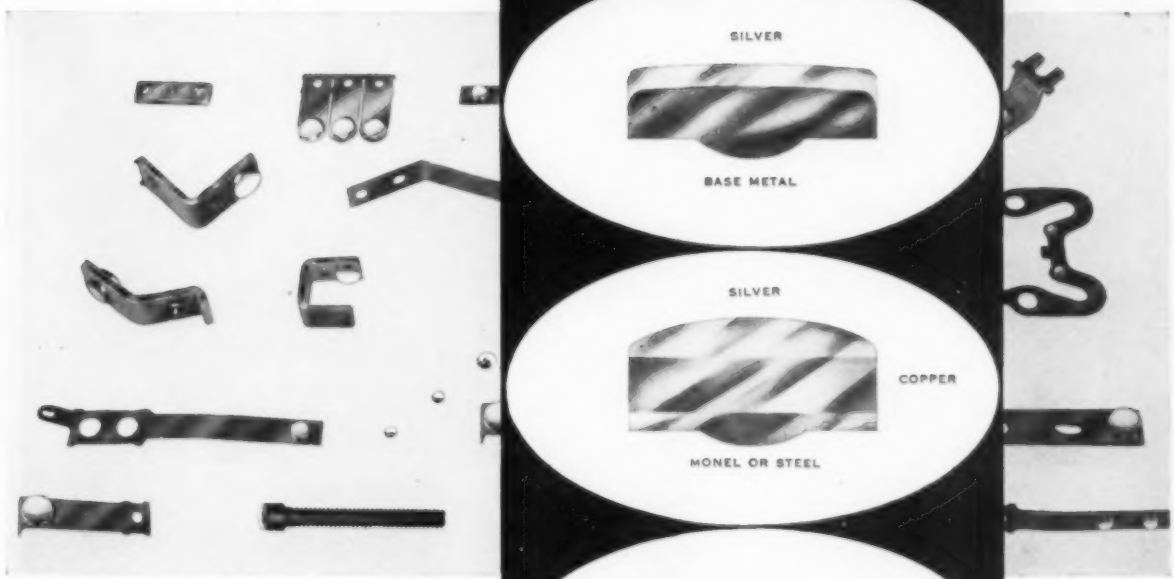
METALS & CONTROLS CORPORATION

Spencer Thermostat Division 3807 Forest Street, Attleboro, Mass.

KLIXON

GENERAL PLATE BUTTON CONTACTS...

Help You Boost Product Performance — Cut Product Costs



Typical General Plate clad projection welding button contacts.

Consider the outstanding features available to you in G. P. clad projection welding contacts:

- **TRIPLE CLAD CONSTRUCTION.** Three ply types have copper between contact face and backing for higher specific heat at lower cost — reduces surface temperature — prolongs operating life.
- **WROUGHT METAL FACES.** Contact face materials in both two and three ply types are work hardened in manufacture — resist deformation — give more operations — better tolerance control.
- **WIDE CHOICE OF MATERIALS.** Contact face materials include silver and platinum group metals and their alloys—silver cadmium oxides—refractory metal mixtures. Backing materials include steel — nickel — nickel-silver and monel.
- **WIDE CHOICE OF SIZES.** Tremendous assortment of standard sizes available to meet all dimensional requirements.

Back of this unusual product versatility, is General Plate Division's team of contact experts — ready to help you get the best performance at the lowest cost. Your inquiries are invited.

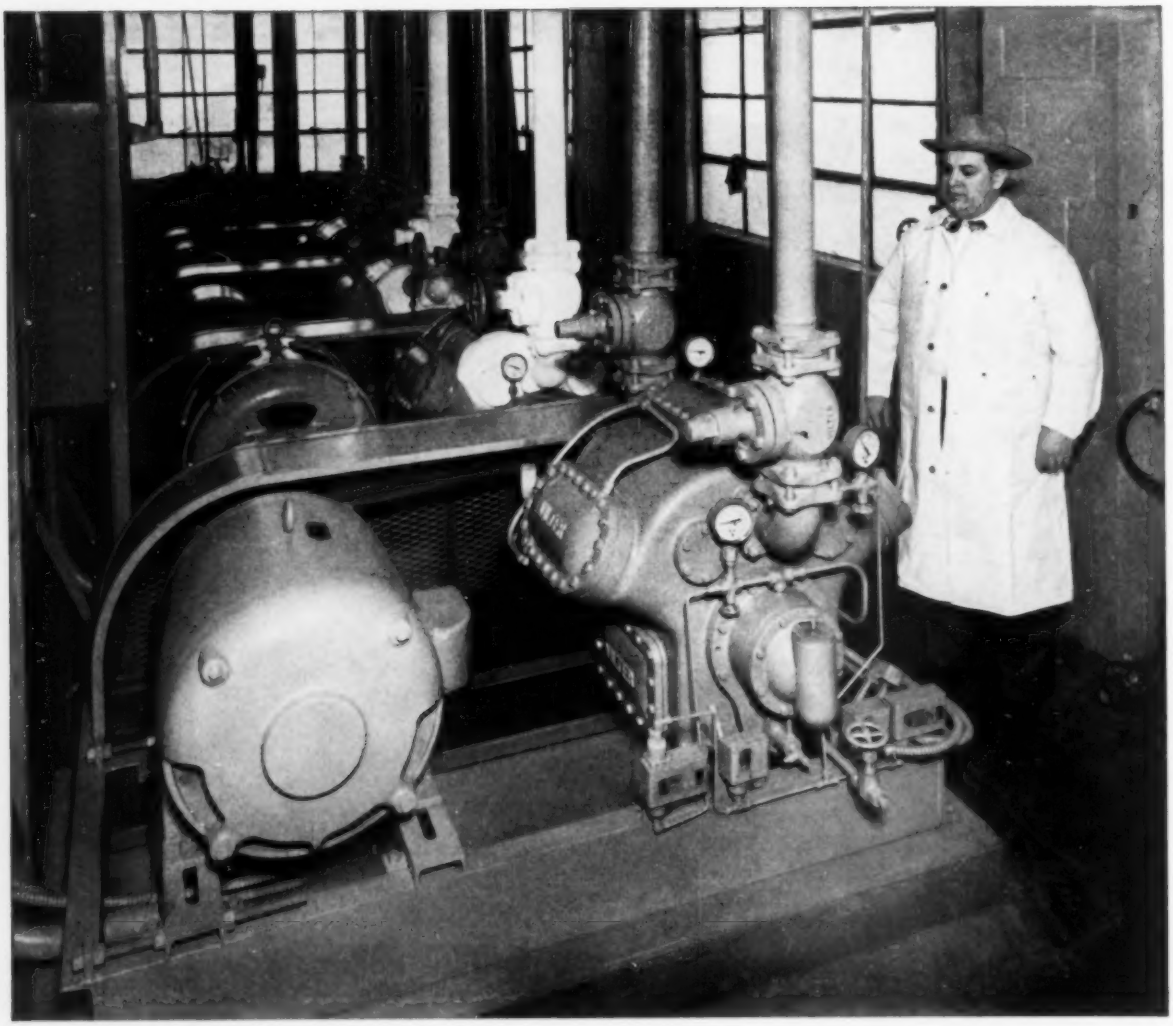
You Can Profit by Using G. P. Clad Metals

METALS & CONTROLS CORPORATION

General Plate Division

1007 Forest Street, Attleboro, Mass.

FIELD OFFICES: NEW YORK, CHICAGO, DETROIT, MILWAUKEE, LOS ANGELES



THE VILTER MANUFACTURING COMPANY REPORTS:

To ensure top efficiency, we use V-belts reinforced with DACRON on our compressor drives

REG. U. S. PAT. OFF.

In keeping with its reputation as a leading manufacturer of refrigeration and air conditioning equipment, The Vilter Manufacturing Company of Milwaukee specifies V-belts reinforced with "Dacron"* for "Freon"** and ammonia compressor drives. These belts, manufactured with Du Pont "Dacron" by Durkee-Atwood, are easy to match . . . pull evenly and efficiently.

V-belts reinforced with "Dacron" give up to 40% more horsepower from belt drives than is possible with other reinforcing fibers. The ability of these belts to withstand greater shock loads, coupled with their longer flex life, results in remarkable durability. They stretch less and are more stable than other belts . . . require far less maintenance. And design men find they can use fewer and smaller belts and sheaves, meeting today's demand for more compact, more economical belt drives.

For the next drive you design or install, consider the advantages of premium V-belts made with "Dacron" polyester fiber made by Du Pont and the high skills of leading manufacturers who make the belts. E. I. du Pont de Nemours & Co. (Inc.), Textile Fibers Department, Wilmington 98, Delaware.

*"*Dacron" is Du Pont's registered trademark for its polyester fiber.*
***"Freon" is Du Pont's registered trademark for its fluorinated hydrocarbons.*

DU PONT

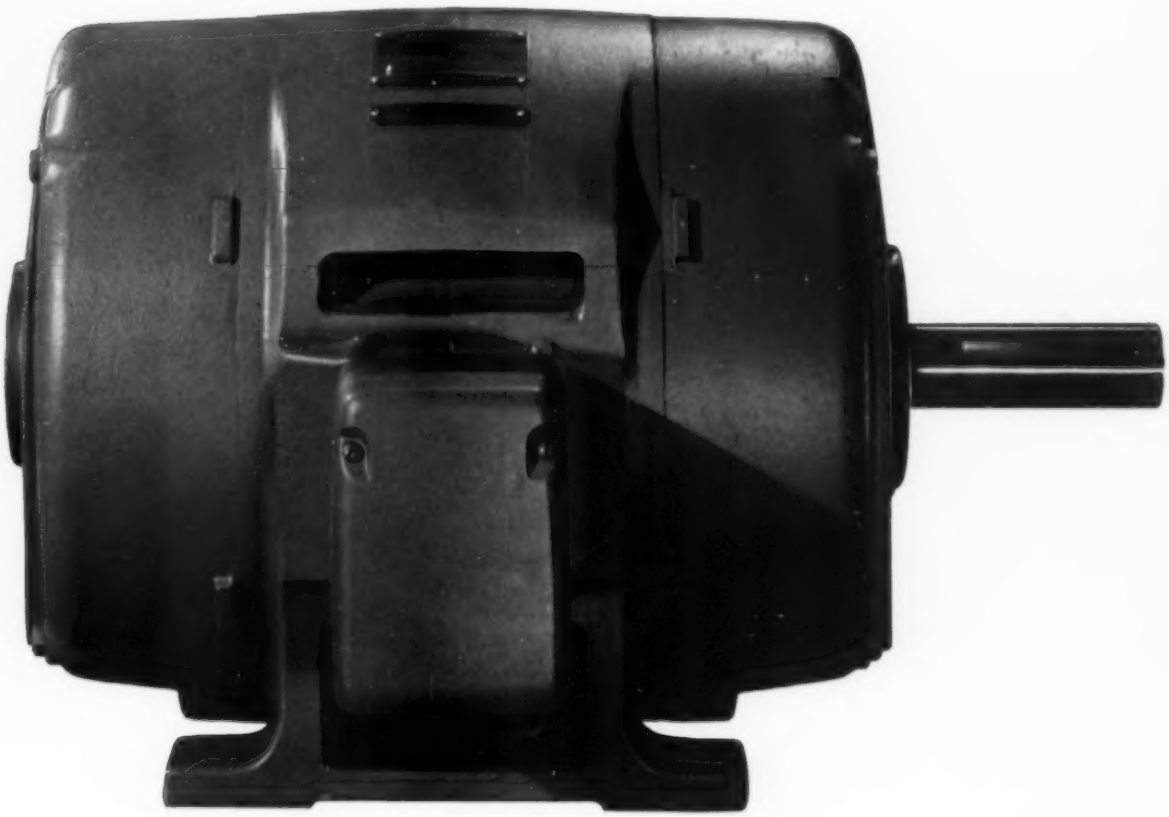
REG. U. S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING . . . THROUGH CHEMISTRY

V-BELTS OF "DACRON" transmit more horsepower . . . stand greater shock loads . . . give longer flex life . . . give greater opportunities for machine-design improvement.

NEW

FROM GENERAL ELECTRIC



TRI 55 CLAD MOTORS

REG. U.S. PAT. OFF.

NOW UP TO 125 HP

GENERAL ELECTRIC

compact . . . power-packed

General Electric TRI 55 CLAD

REG. U.S. PAT. OFF.

NOW UP

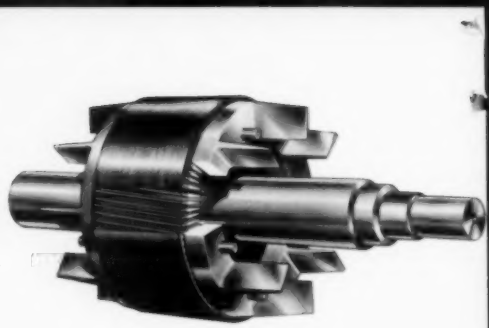
DRIPPROOF

DESIGNED, BUILT AND TESTED FOR

FULLY PROTECTED by cast-iron enclosures, Tri-Clad '55' motors handle many jobs where ordinary drippproof motors cannot be applied.

MYLAR* slot insulation, Formex® wire, non-wicking Geoprene® leads and Dri-Film® silicone coating increase stator life up to 50%.

*Registered Trade-mark Dupont Co.



IMPROVED ROTORS are solid cast of pure aluminum for greater strength, higher conductivity. Rotor bars are insulated from core to improve motor efficiency.

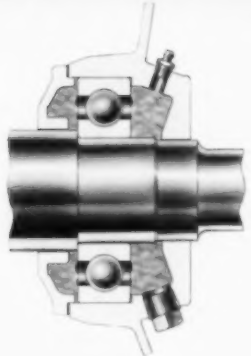
GENERAL ELECTRIC

Motors in New NEMA Ratings

TO 125 HP

TOTALLY ENCLOSED

LONGER LIFE, EASIER MAINTENANCE



BEARING SYSTEM uses over-size ball bearings, synthesized grease, long, close-running seals to extend motor life.

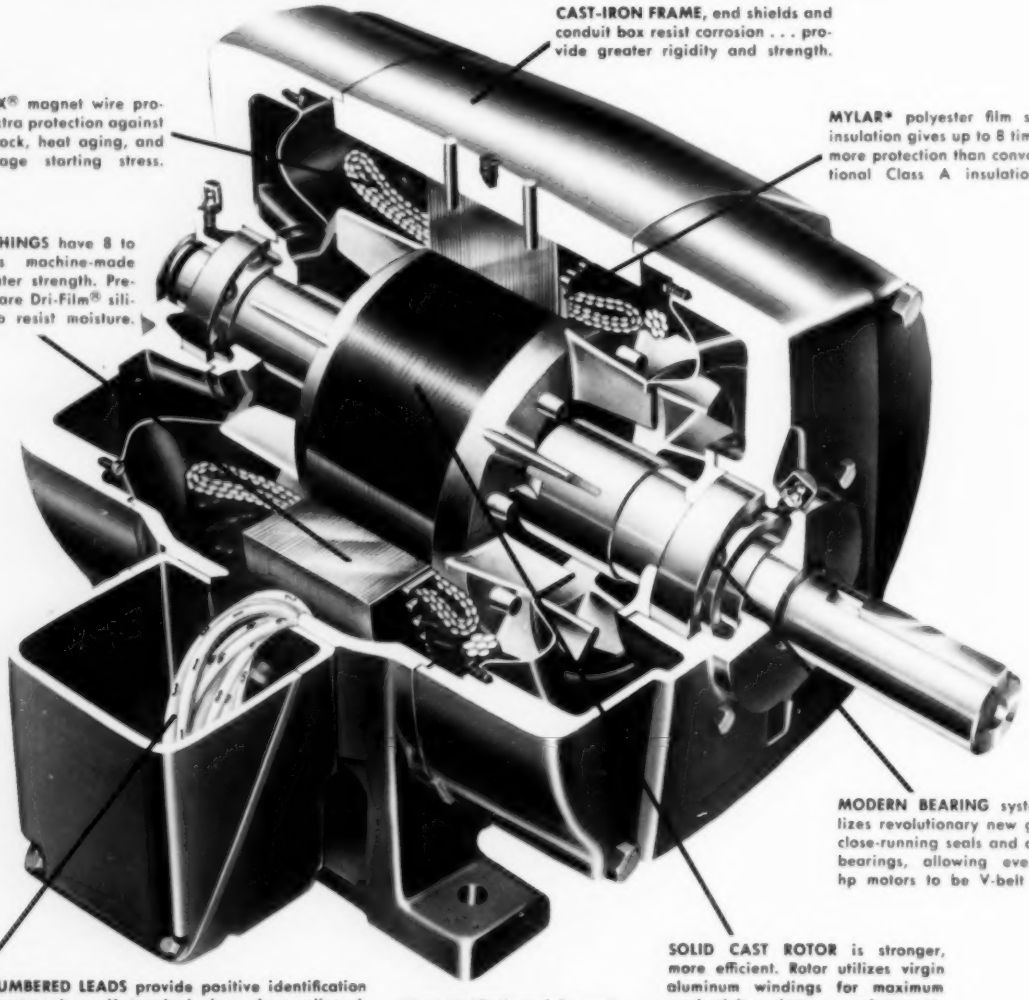
PERMA-NUMBERED LEADS and roomy conduit box facilitate motor hook-up. Knock-off lugs speed end shield removal for motor inspection.

GENERAL ELECTRIC Tri-Clad '55' motors must pass a series of sound, vibration and hi-potential tests prior to shipment. Rigid tests assure uniform high-quality, and long-life performance.

TRI-CLAD motors give you top performance. Here's why . . .

compact . . . power-packed

Only G-E TRI 55 CLAD motors give you all these years-ahead benefits



CAST-IRON FRAME, end shields and conduit box resist corrosion . . . provide greater rigidity and strength.

FORMEX® magnet wire provides extra protection against heat shock, heat aging, and full-voltage starting stress.

MYLAR* polyester film slot insulation gives up to 8 times more protection than conventional Class A insulations.

STATOR PUNCHINGS have 8 to 16 continuous machine-made welds for greater strength. Pre-wound stators are Dri-Film® silicone-treated to resist moisture.

MODERN BEARING system utilizes revolutionary new greases, close-running seals and oversize bearings, allowing even 125-hp motors to be V-belt driven.

PERMA-NUMBERED LEADS provide positive identification even when taped, or if terminals have been clipped.

SOLID CAST ROTOR is stronger, more efficient. Rotor utilizes virgin aluminum windings for maximum conductivity, better performance.

*Registered Trade-mark Dupont Co.

FOR COMPLETE INFORMATION

Section 891-3
GENERAL ELECTRIC COMPANY
Schenectady 5, New York

Please send me the following publications:

☐ **FREE BULLETIN** (GEA-6602) describing the many advanced features of new Tri-Clad '55' motors up to 125-hp.

☐ **FREE SLIDE RULE** (GEN-148) to determine weight and space-saving benefits of new Tri-Clad '55' motors.

NAME _____

TITLE _____

COMPANY _____

ADDRESS _____

CITY & STATE _____

FOR COMPLETE DETAILS on the new line of Tri-Clad '55' motors up to 125 hp, contact your local G-E motor distributor or the motor specialist at your nearby General Electric Apparatus Sales Office. They will give you expert assistance in selecting and applying the right motor for your particular application.

For free slide rule to determine weight and space-saving benefits of the new motor, and for informative General Electric Tri-Clad '55' motor bulletin, please send attached coupon.

Progress Is Our Most Important Product

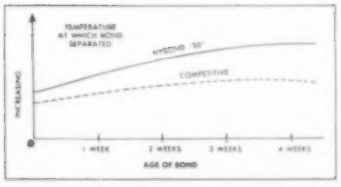
GENERAL ELECTRIC

PIERCE & STEVENS
CHEMICAL CORP.
ADHESIVES • COATINGS

P&S ADHESIVE DIGEST

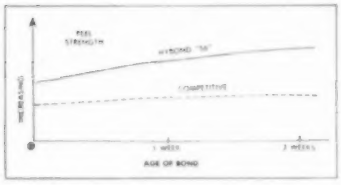
LATEST DEVELOPMENTS IN ADHESIVES FOR INDUSTRY

COMPARATIVE ANALYSIS



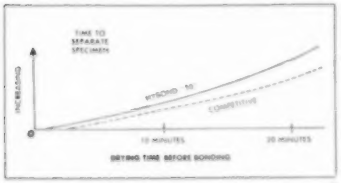
HEAT RESISTANCE

Plastic laminate bonded to wood. Specimen placed in oven under dead load in sheer. Temperature increased at constant rate until separation occurs. HYBOND "56" provides greater resistance to surface heats and the high storage temperature to which many finished products are subjected.



PEEL STRENGTH

Fabric-backed linoleum to steel. Peel strength determined on Scott tester. This chart demonstrates HYBOND "56" greater peel strength. HYBOND reaches a strength of 15 lbs. per inch at the end of two weeks.



RESISTANCE TO DEAD LOAD

Fabric-backed linoleum bonded to steel. Specimen 1" wide subjected to dead load immediately after bonding. Demonstrates HYBOND's ability to offer greater resistance to "fight" of surfacing materials when required to conform to contour.

MASS PRODUCTION LAMINATING MADE POSSIBLE BY NEW CONTACT ADHESIVES

Thanks to latest developments in the field of chemical bonding, mass production techniques now prevail in more and more industrial laminating operations. Inseparable in this trend are *sprayable* contact adhesives which provide fast drying, instantaneous bonds. In consequence, these features eliminate the need for clamps, presses and complicated heat-curing schedules which retard production and increase cost burdens.

Typical of these highly-functional, time-saving adhesives is HYBOND "56" recently introduced by Pierce & Stevens Chemical Corp. HYBOND "56" is a fast-setting, *sprayable,* synthetic rubber adhesive designed especially for high-speed production schedules involving the bonding of a wide variety of dissimilar materials — plastic laminates, plywood, steel, aluminum, fibreboard, rubber, leather, fabric, paper honeycomb, etc. HYBOND "56" has proven particularly effective in the mass production bonding of counter and desk tops, porcelainized metal chalk boards, honeycomb partitions, "curtain-walls" and trailer bodies.

HYBOND "56" symbolizes progress in contact adhesives — offers these real advantages:

Greater peel strength — in laboratory and field tests of linoleum bonds to metal, the linoleum ruptures while the bond persists.

Higher heat resistance — provides a greater safety factor when bonded products are exposed to high temperatures.

Greater dead-load strength — yet sufficiently elastic to resist shock and fatigue.

HYBOND "56" is spray-applied — dries within minutes to the tacky condition required for bonding — adheres instantly when the cemented surfaces are joined. The final bond is odorless, non-staining and highly resistant to moisture, oil, grease and many chemicals.

Complete technical data on HYBOND "56" may be obtained by mailing the handy coupon. No obligation, of course.

P&S SINCE 1884

PIERCE & STEVENS CHEMICAL CORP.
Dept. P-1
710 Ohio Street, Buffalo 3, N. Y.

Please send complete technical data on HYBOND "56". Also send copy of comprehensive P&S Product Catalog as illustrated at left.

Name _____

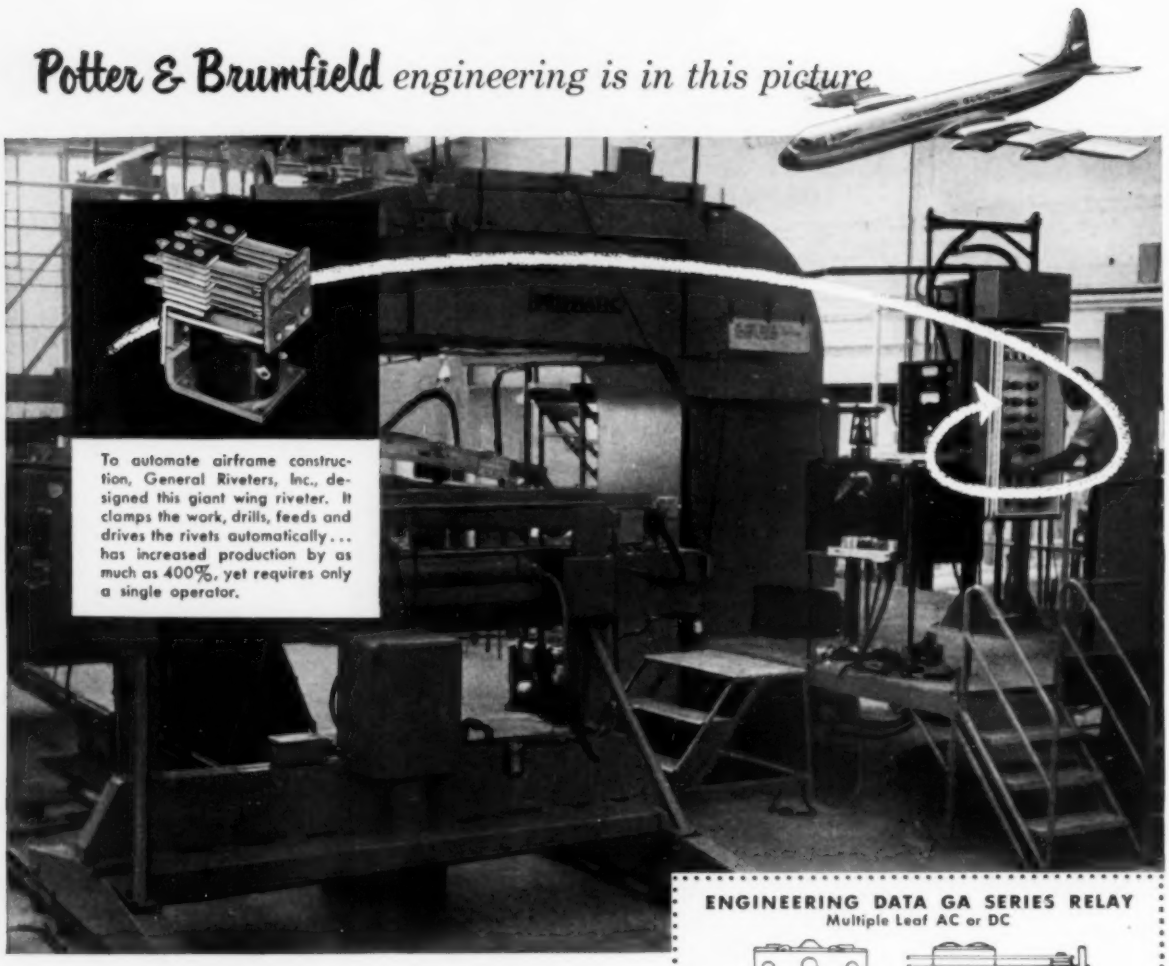
Title _____

Company _____

Address _____

City _____ State _____

Potter & Brumfield *engineering is in this picture*



To automate airframe construction, General Riveters, Inc., designed this giant wing riveter. It clamps the work, drills, feeds and drives the rivets automatically... has increased production by as much as 400%, yet requires only a single operator.

P&B RELAYS AUTOMATE THIS GIANT RIVETER *for new Lockheed Electra Wings*

This new automatic riveter will be used to make wings for the new Lockheed Electra, a prop-jet luxury liner, as well as many other modern aircraft. The heart of this riveter is a relay circuit that "takes orders" from a pattern of holes punched in 35 mm film strips.

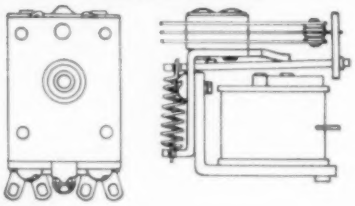
General Riveters, Inc. selected the GA Series P&B relay for the control circuits of this riveter because of its unusual dependability and versatility. In adapting this relay to a specific application, P&B's engineers again demonstrated how 25 years of creative engineering can pay off by providing a standard type or completely new relay to solve your particular problem. Write today for new compact catalog or engineering consultation.

P&B Standard Relays are available at your local electronic, electrical and refrigeration distributors

Potter & Brumfield, inc.

PRINCETON, INDIANA *Subsidiary of* AMERICAN MACHINE & FOUNDRY COMPANY
Manufacturing Divisions also in Franklin, Ky. and Laconia, N. H.

ENGINEERING DATA GA SERIES RELAY
Multiple Leaf AC or DC



CONTACTS
Material: 3/16" fine silver (other contact materials can be furnished for specific applications)
Rating: 5 amp. 115 V. 60c non-inductive load
Arrangements: 4 Form C Max., AC; 6 Form C Max., DC
Breakdown: 1000 V. RMS between all elements

COIL
Resistance: 30,000 ohms max.
Power req'd: 6 W. max., 2 W. min. DC at 25° C. ambient
V range: DC to 110 V.; AC to 230 V.

DIMENSIONS, MAX.
1 23/32" L. x 1 1/16" W. x 1 25/32" H.

MOUNTING DATA
4 tapped #6-32 holes, .750" x .875" o.c. 1 tapped #8-32 core

ENCLOSURES
Hermetically sealed, octal plug: 2 17/32" x 1 29/32" x 1 25/32"
Multiple solder header and miniature plug-in: 2 15/32" x 1 29/32" x 1 25/32"
Special container required for 6 Form C

TERMINALS
Contacts: two #16 AWG wires
Coil: two #20 AWG wires

See our catalog in Sweet's Product Design File

Eagle Manufacturing Company, Wellsburg, West Virginia, called on Weirkote's deep-drawing capabilities for its new, seamless gasoline and oil cans

WEIRKOTE® ZINC-COATED STEEL CAN BE SHAPED TO ANY PRODUCT SPECIFICATIONS!

Using Weirkote zinc-coated steel, the Eagle Manufacturing Company gives us a much needed improvement in gasoline and oil can construction. A container with a smooth, seamless-drawn, dome-shape shell.

Result? This smooth, dome-shape top leaves no place for grease, dirt and moisture to collect. And by eliminating top and side seams, chance of leakage is almost nil. (There's a double-seamed bottom, further insuring a leak-proof container!)

Eagle uses Weirkote for this tough drawing job for these specific reasons: Weirkote zinc-coated steel can be worked and shaped to the very limits of the steel base itself. Its zinc-coated "skin" will not flake or peel under even the most severe fabricating stress. Thus, any chance of corrosion is eliminated.

Here's a material for your product that combines the corrosion resistance of zinc with the proven superior strength of steel. And Weirkote has the inherent flexibility to completely "obey" *all* your shaping stresses.

Weirkote will form to *your* requirements, too. Let us show you how it can do any job for you—*better!* Send today for free booklet on Weirkote. Write Weirton Steel Company, Dept. D-19, Weirton, West Virginia.

WEIRTON STEEL COMPANY

WEIRTON, WEST VIRGINIA

a division of

NATIONAL STEEL CORPORATION

Why designers specify FLEXLOC self-locking nuts

Where products must be tough . . . must stand up under vibration, shock and abuse . . . designers specify rugged, reliable, precision-built FLEXLOC self-locking nuts as fasteners.

HERE'S WHY:

FLEXLOC locknuts are strong: tensile strengths far exceed accepted standards. They are uniform: carefully manufactured to assure accurate, lasting spring tension in the flexible locking collars. And they are reusable: rough screw threads, repeated removal and replacement, frequent adjustments will not affect their locking life.

Standard FLEXLOC self-locking locknuts are available in a wide range of standard sizes and materials, to meet the most critical locknut requirements. Your authorized industrial distributor stocks them. Write us for complete catalog and technical data. Flexloc Locknut Division, STANDARD PRESSED STEEL CO., Jenkintown 28, Pa.

FLEXLOC® LOCKNUT DIVISION

STANDARD PRESSED STEEL CO.

SPS

JENKINTOWN PENNSYLVANIA

Design data on adhesives

Armstrong

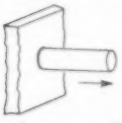
NUMBER TWO

ADHESIVES • COATINGS • SEALERS

Strengthening a common angle joint

In redesigning a common angle joint (or any other ordinary joint) to give maximum strength with adhesives, four basic rules must be kept in mind.

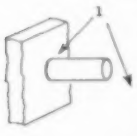
1. Make the bonded area as large as possible.
2. Make the maximum proportion of bonded area contribute to strength.
3. Stress the adhesive in the direction of its maximum strength.
4. Minimize stress in the direction in which the adhesive is weakest.



Here's how these rules can be applied:

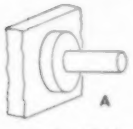
If the load is in the direction of the arrow, then stress distribution will yield high strength.

If the load is not exactly at right angles to the plane of the joint, the result will be a concentration of stress, a cleavage force (in this case at 1).



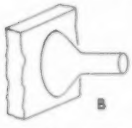
REMEDY

A. Increase area (better)



Bonded area has been made as large as possible. (Rule 1) Maximum proportion of bonded area now contributes to strength. (Rule 2)

B. Increase area and reduce stiffness at edge of joint (best)



Bonded area has been made as large as possible. (Rule 1) Maximum proportion of bonded area now contributes to strength. (Rule 2) Stress is now minimized in the direction in which the adhesive is weakest. (Rule 4)

If you have a design problem involving adhesive bonding, we may be able to suggest a practical, economical solution based on our 36 years of experience in making and using adhesives, coatings, and sealers. Send details of your problem to Armstrong Cork Company, Industrial Div., 8007 Irvin St., Lancaster, Pa.

How to prepare surfaces for bonding

To attain optimum results with adhesives, the surfaces of the materials to be bonded must be clean. The amount of surface preparation necessary may be influenced by the type of adhesive used or the ultimate requirements of the bond.

Nonstructural adhesives, such as the pressure-sensitive or contact types, rubber cements, and asphalt adhesives, perform satisfactorily if the surface is free of dust and dirt, grease and oil, loose scale and corrosion products.

Where high-strength bonds are required, surface preparation must be more thorough. Chemical cleaning is preferred where the size of the production operation warrants installation of the proper equipment. Mechanical methods are desirable on operations where the number of assemblies to be bonded is small or where chemical cleaning would cause deterioration of part of the assembly.

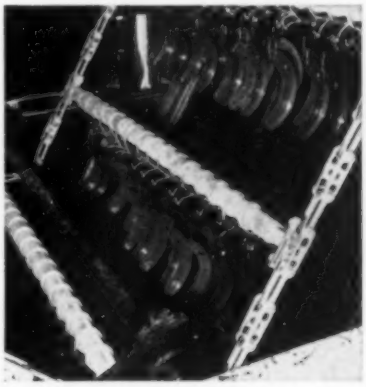


PHOTO COURTESY CHEVROLET-DETROIT GEAR AND AXLE DIV., GENERAL MOTORS CORP.

Before bonding, brake shoes are washed and pickled, then immersed in varnish dip and dried.

Listed below are typical procedures for cleaning materials frequently fastened by adhesives.

Aluminum may be cleaned with acidic or alkaline cleaners. Preferred alkaline cleaner of sodium metasilicate and a wetting agent in water at a temperature of 160° to 180° F. cleans aluminum in 4 to 5 minutes. Aluminum should be immediately rinsed with water. (A chromic acid rinse after alkaline cleaning prevents corrosion by residual alkali.)

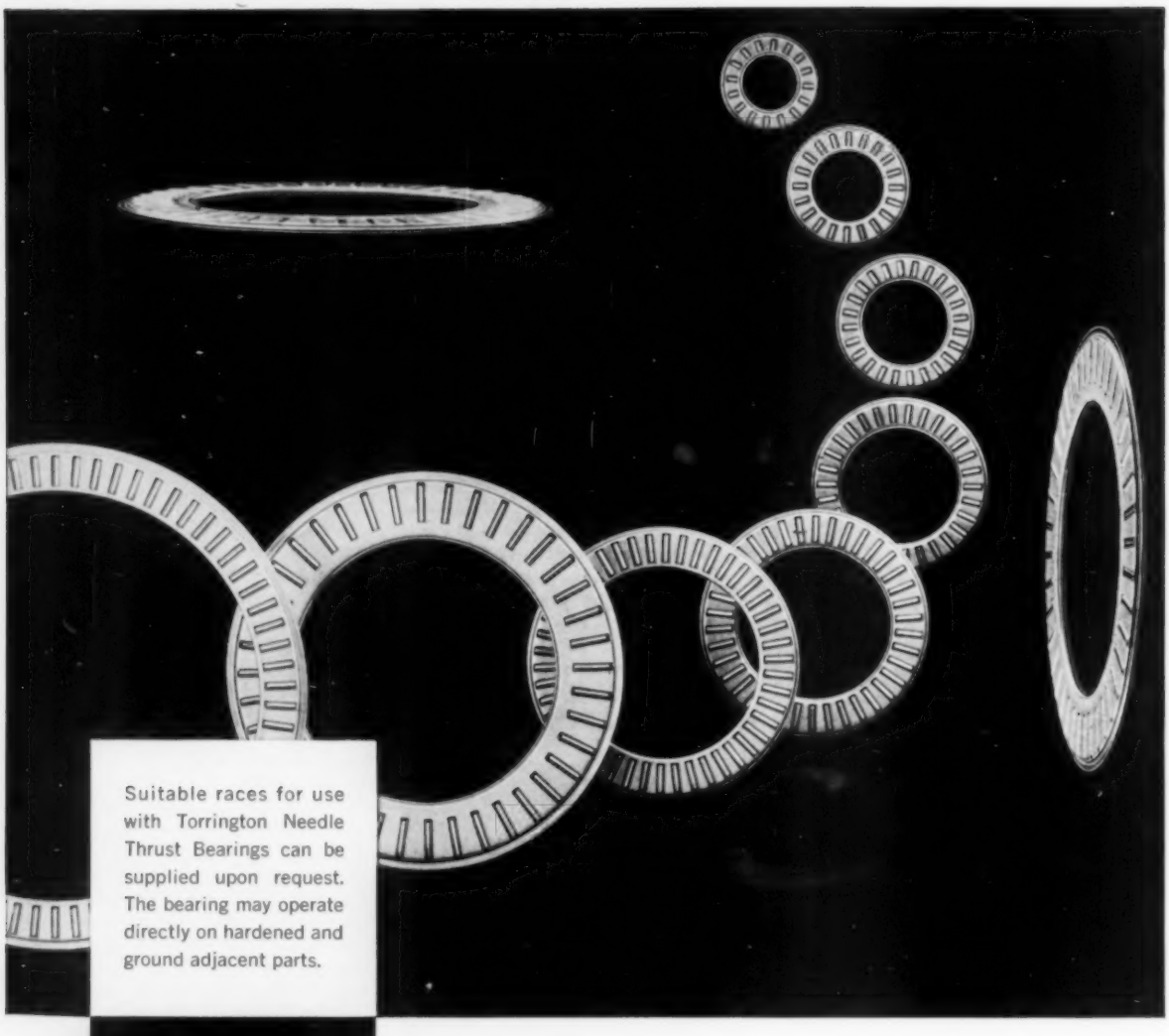
Cleaning methods for spot welding are satisfactory for bonding. Preferable acidic cleaner consists of a solution of sulphuric acid and sodium dichromate at 140° to 160° F.

Steel should be free of rust and mill scale as well as dirt and grease. Use an alkaline cleaner to remove grease and dirt and follow with an acid pickling operataion. (Pickling of high-carbon steel and certain alloys often leaves a smut or residue which may be removed mechanically while wet or chemically with oxidizing agents.) Clean steel parts should be coated immediately to prevent rust formation.

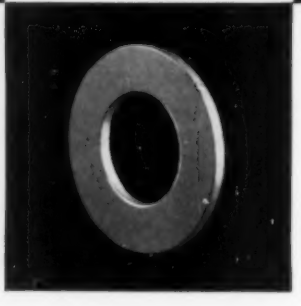
Magnesium may be cleaned by brushing lightly with a fine wire brush followed by hot alkaline cleaner and water rinse, or by anodizing. Magnesium supplied with conventional surface treatments sometimes can be used as is, but surface contamination should be removed with solvent. Common practice in the aircraft industry, for example, is to clean the metal, apply coat of zinc-chromate primer, and bond right over it.

Plastics should be sanded prior to bonding to remove mold finish and mold release agents. Flexible vinyl plastic sheets normally require no cleaning other than surface dirt removal. Other plastics may be wiped with a solvent; however, true solvents for the plastic normally should not be used as they may cause distortion, excessive softening, crazing and cracking.

Vulcanized Rubber parts are often contaminated with mold release agents or by plasticizer or wax exudation. Silicone mold release agents prevent good bonds, as the silicone greatly impairs adhesion to the rubber. Remove talc and water-soluble mold-release agents by washing with water; plasticizer and wax, by washing with solvent. Solvent used depends on the specific rubber; toluol generally is satisfactory, but it should be used with care, since it attacks some types of rubber. Light abrasion of the rubber surface improves adhesion.



Suitable races for use with Torrington Needle Thrust Bearings can be supplied upon request. The bearing may operate directly on hardened and ground adjacent parts.



Torrington's new Needle Thrust Bearing grows in popularity...and range of sizes

Designers have been quick to take advantage of the compactness, high thrust capacity and low unit cost of Torrington's new Needle Thrust Bearing.

To meet the growing demand for this bearing in automatic transmissions, governors, steering gears, bevel gears, hydraulic pumps, torque converters and many other applications, tooling has been completed to produce bearings ranging from .500" ID to 3.000" ID.

Only .0781" thick, the Torrington Needle Thrust Bearing is thin as an ordinary thrust washer, yet brings all the advantages of anti-friction operation to applications where space is limited. Mating steel retainer halves are joined securely to form a self-contained unit that is easy to handle and install.

Plan today to evaluate the Torrington Needle Thrust Bearing. Services of our Engineering Department are available to help you. For full information, write for Bulletin No. 16, "Torrington Needle Thrust Bearings." *The Torrington Company,* Torrington, Conn.—and South Bend 21, Ind.

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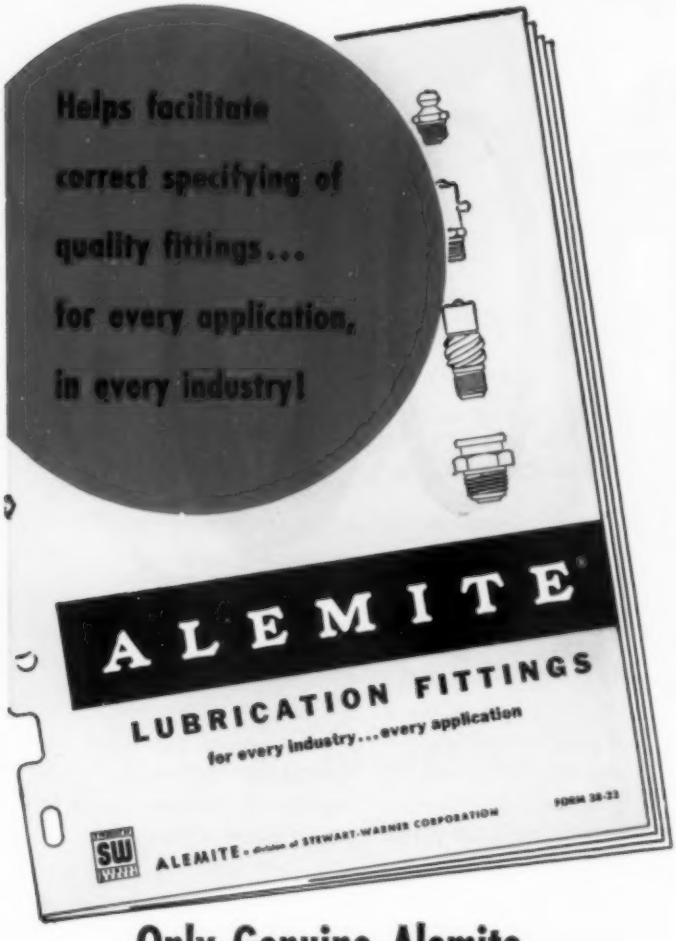

Here is Alemite's new free catalog of the most *complete* line of fittings on the market! A simple, handy guide to fast, easy selection of the right fitting for every requirement. Contains detailed drawings of all Alemite fittings including the famous Alemite "Red-Ball" Hydraulic Fittings. Also lists many types of fittings that have been developed for special purposes—including relief fittings, measuring fittings and drive fittings. Complete with individual dimensions—ready for transfer to your own blueprints. Fill out the coupon below. Send for your new full-line catalog of Alemite Fittings today!

Only Genuine Alemite Red-Ball Fittings Offer These Four EXTRA Advantages!

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3. Tip has rounded contour to give extra working angle. No ridges . . . coupler won't slip off in tight quarters!

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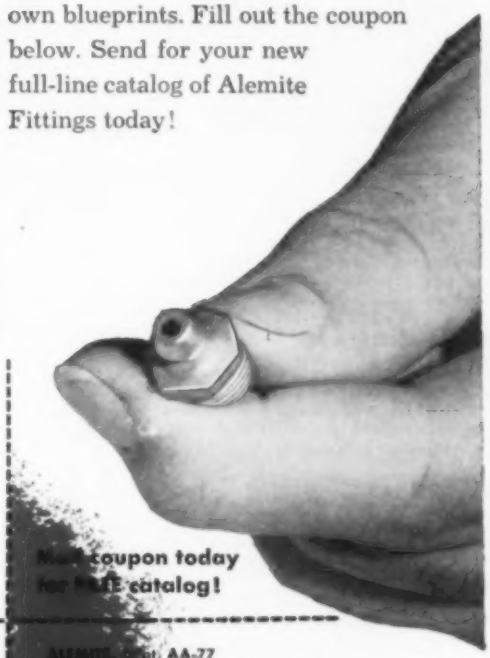

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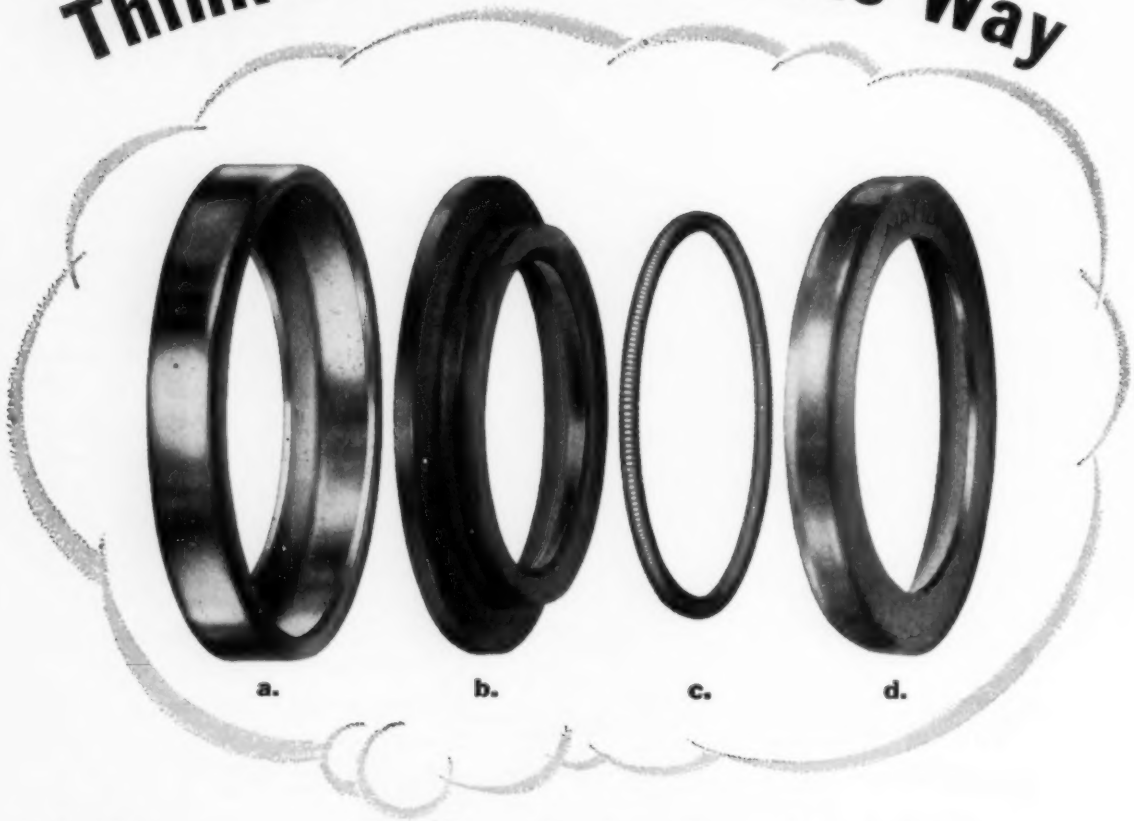

a. Outer Case

Formed to extreme close tolerance of heavy gauge steel with sufficient structural strength to maintain precision dimension.

b. Sealing Lip

Properly prescribed material either compounded or processed for application conditions of temperature and eccentricities. Precisely molded for correct shaft interference, low torque and positive sealing.

c. Tension Spring

Carefully engineered as to metallurgy, heat treatment and coil diameter to provide uniform compressive force on the sealing element.

d. Inner Case

Strengthens, protects; sturdy gauge steel formed to close tolerances.

4227

A good oil seal is a carefully engineered, precision manufactured assembly of carefully engineered, precision manufactured components. Each part must be exactly right *for the given application* or the seal will not function properly.

You avoid dangers of costly retooling, remanufacture or premature replacement when seals are correctly specified during your product's design stage. Each sealing application is different; many designers use National's field engineering service to be sure correct—and latest—oil seals are used.

Why "do it yourself?" Call the National Seal field engineer now. His service involves no obligation.

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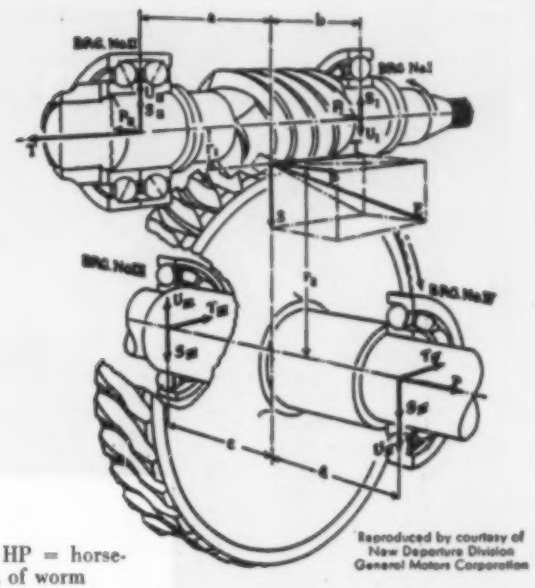
Helpful Data from DE LAVAL

How to Calculate Worm Gear Bearing Loads



Reproduced by courtesy of New Departure Division General Motors Corporation

$Q = \frac{HP \times 63025}{N}$ = TORQUE INPUT to worm, lbs. inches; HP = horsepower transmitted and N = rev. per min. of worm

$P = \frac{Q}{r_f}$ = TANGENTIAL FORCE of worm, where

r_1 = Pitch radius of worm in inches

[r_2 = Pitch radius of worm gear

$= \frac{1}{2\pi}$ (number of teeth in gear x axial worm pitch)]

$S = \frac{P \tan \alpha}{\tan \gamma}$ = SEPARATING FORCE, where

α = Axial tooth pressure angle*

γ = Helix or lead angle of worm*

$= \tan^{-1} \frac{\text{lead}}{2\pi r_1}$, or $\tan^{-1} \frac{\text{Number of threads x axial worm pitch}}{2\pi r_1}$

$T = \frac{P}{\tan \gamma}$ = WORM THRUST, or tangent force driving worm gear

* LEAD ANGLE 0°-35° use 27½° Pressure Angle
LEAD ANGLE 35°-45° use 30° Pressure Angle

BEARING LOADS

Due to	on Brg. I	on Brg. II
P	$P \frac{a}{a+b} = P_I$	$P \frac{b}{a+b} = P_{II}$
S	$S \frac{a}{a+b} = S_I$	$S \frac{b}{a+b} = S_{II}$
T	$T \frac{r_1}{a+b} = U_I$	$T \frac{r_1}{a+b} = U_{II} = U_I$
Total Rad. Load	$\sqrt{P_I^2 + (S_I - U_I)^2}$	$\sqrt{P_{II}^2 + (S_{II} + U_{II})^2} = R_{II}$
Thrust Load		T
Total Load	$\sqrt{P_I^2 + (S_I - U_I)^2}$	$\sqrt{R_{II}^2 + T^2}$

Due to	on Brg. III	on Brg. IV
P	$P \frac{r_2}{c+d} = U_{III}$	$P \frac{r_2}{c+d} = U_{IV} = U_{III}$
S	$S \frac{d}{c+d} = S_{III}$	$S \frac{c}{c+d} = S_{IV}$
T	$T \frac{d}{c+d} = T_{III}$	$T \frac{c}{c+d} = T_{IV}$
Total Rad. Load	$\sqrt{T_{III}^2 + (U_{III} - S_{III})^2}$	$\sqrt{T_{IV}^2 + (S_{IV} + U_{IV})^2} = R_{IV}$
Thrust Load		P
Total Load	$\sqrt{T_{III}^2 + (U_{III} - S_{III})^2}$	$\sqrt{R_{IV}^2 + P^2}$

Speed Change

$$\text{Gear rpm} = N \times \frac{\text{Number of threads in worm}}{\text{Number of teeth in gear}}$$

For simplicity in bearing load computations for worm gearing, the normal tooth force E is treated in terms of its three perpendicular elements, namely, P, the tangential driving force at pitch radius of worm; S, the force tending to separate worm from the gear, due to the pressure angle; and T, the thrust produced by the lead or helix angle of the worm.

If you have a problem in the selection or application of worm gearing, De Laval engineers will be glad to put their experience to work for you. Either write us giving complete details, or consult your local De Laval representative.
De Laval Steam Turbine Company,
801 Nottingham Way,
Trenton 2, New Jersey

EXON 470...specifically for protective coatings at lower costs

...typical of the Pin-Pointed Properties in Exon Vinyl resins

Manufacture of solution protective coatings takes a giant stride toward simpler processing and lower costs when you use Exon 470. You no longer need several resins to get the best properties of them all. One is enough . . . Exon 470.

With only one resin to work with, production control is simplified. Costs drop. At the same time you cut your inventory expenses. You produce a better product with outstanding solution characteristics.

Here are just a few of the important properties combined in Exon 470: Adhesion to metal, alkyd and vinyl surfaces. High solubility in aromatic hydrocarbons. Alkyd compatibility. Excellent pigment dispersion properties. Abrasion, acid and alkali resistance. Fast baking . . . medium fast drying. Oil, grease and salt-spray resistance. Low moisture vapor permeability. Outdoor durability. Now you need only one resin . . . Exon 470 . . . to make better solution coatings at lower costs.

Exon 470 is just one of the many resins in industry's most complete line of versatile vinyls. It is another reason why industry looks to Firestone for engineering answers to its needs.

Consider your own production problem. Then, for resin properties pin-pointed to the best answer for you, check with Firestone.

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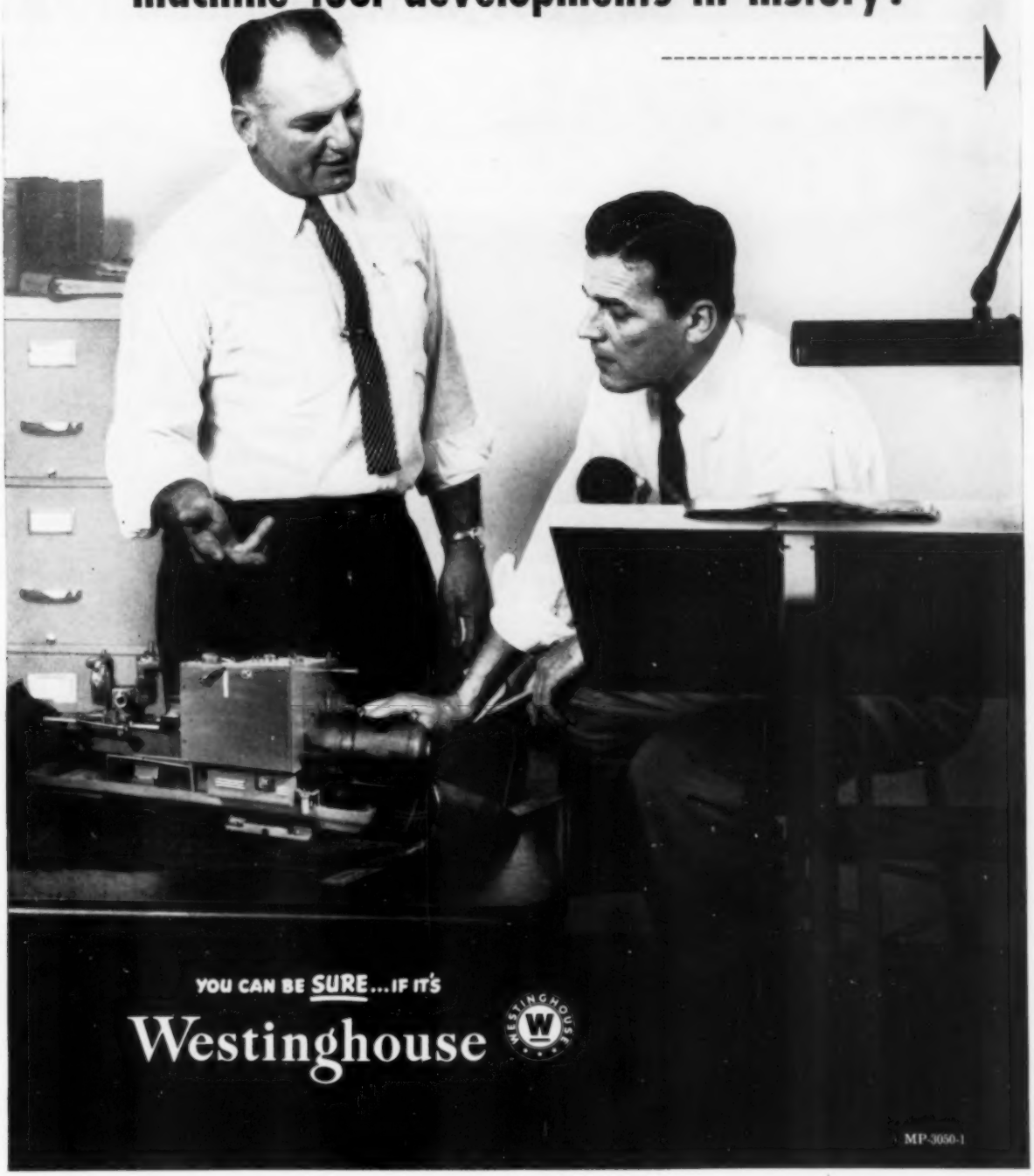
Westinghouse components and services will help you pioneer the greatest machine tool developments in history!



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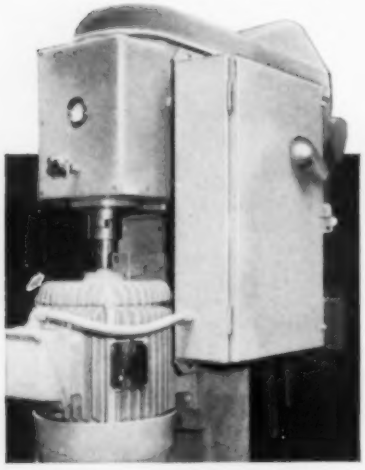
Westinghouse

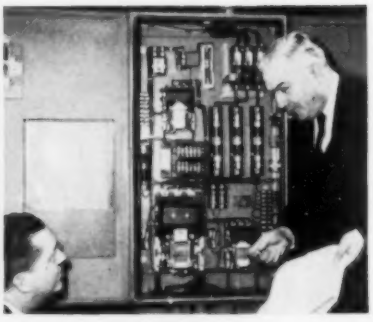
MP-3090-1

NEW DEVELOPMENTS FROM WESTINGHOUSE . . .

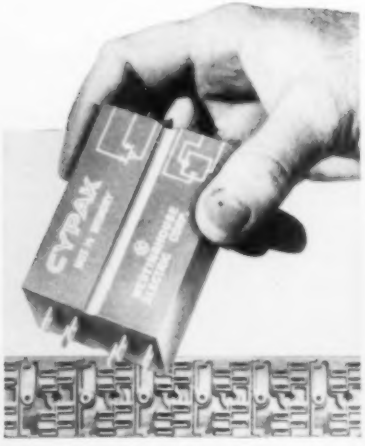
Improve drive and control functions on your new machine tools



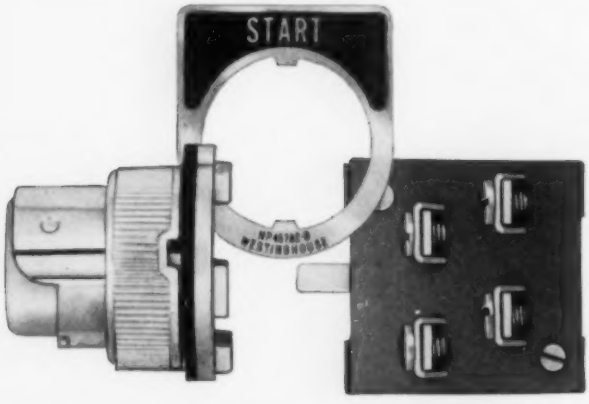
Eighty light-load reversals per minute and no overheating . . . with Westinghouse Life-Line® "A" motors. Reliable performance under severe duty cycles lets you plan greater versatility for machine tools.



Cushioned start of connected load is assured by Westinghouse magnetic reduced-voltage starters. Add-A-Part feature provides flexibility for design and future change-over.



Cypak control has no moving parts to wear, corrode or jam. Service life is 15 times that of mechanical relays, maintenance and down time virtually eliminated. Cypak systems are compact, light, easy to modify.



Just 38 Westinghouse Oil-Tite* pushbutton components . . . standardized, interchangeable, always available from stock . . . offer up to 1,500,000 pushbutton control arrangements—cut space, inventory needs. *Trade-Mark

Westinghouse machine tool transformers take one-third less space, exceed NEMA regulation standards by 30%. Add-A-Part fuse blocks and breakers extend design selection, reduce transformer inventories.

The growing trend to faster specialized machine tools with more automatic operation makes design of compact, dependable drive and control systems for your products more vital than ever. Westinghouse has recently contributed many significant electrical developments to machinery builders that promise great strides in machine tool progress.

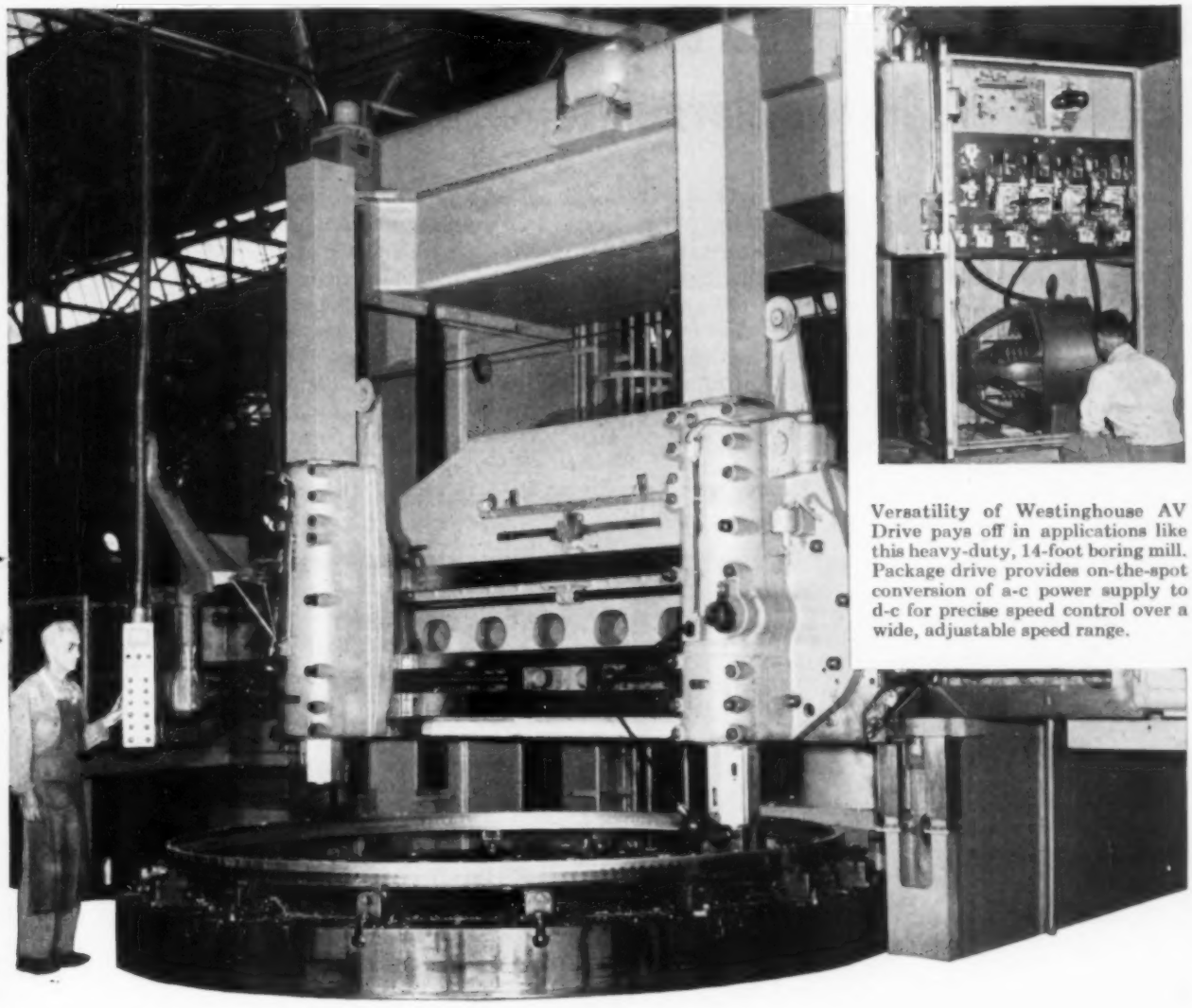
For example, there's Cypak*, a revolutionary development of Westinghouse research for reliable electrical control for machine operations, processes, and coordinated handling of materials. *It has no moving parts* to wear, corrode or jam . . . assuring long life and dependability.

Contactless limit switches, industrial electronic components unsurpassed in performance, improved-design motors, and numerous other product refinements and innovations point to Westinghouse as the electric components supplier for your machine tools.

Developments like these will help you design and build machine tools that better satisfy your customers through increased productivity, reduced inspection and maintenance, and more precise operation. Whatever the function you want performed . . . sensing, transmitting, recording, computing, control, or driving . . . think of Westinghouse components first.

*Trade-Mark
MP-3050-2

YOU CAN BE SURE . . . IF IT'S Westinghouse



Versatility of Westinghouse AV Drive pays off in applications like this heavy-duty, 14-foot boring mill. Package drive provides on-the-spot conversion of a-c power supply to d-c for precise speed control over a wide, adjustable speed range.

Westinghouse service and facilities back up product performance

Your local Westinghouse representative should be a member of your machine design team. He is trained to give you the full benefit of Westinghouse engineering and development information in analyzing your machinery electrification problems.

Westinghouse facilities are located in industrial centers from coast to coast. Westinghouse research . . . field engineering service . . . local manufacturing and repair plants . . . renewal parts stocks . . . all have been established to benefit you and your customers.

The Machine Tool Electrification Forum, sponsored annually by Westinghouse during the past 21 years, is an example of Westinghouse participation and cooperation with the machine tool industry. New ideas fostered and exchanged at such meetings help speed machine tool advances.

When you specify components, choose Westinghouse and be *sure*. You get one-supplier responsibility for products of outstanding quality, backed by more than 70 years of electrical experience. And, Westinghouse components help sell your products. Westinghouse Electric Corporation, 3 Gateway Center, P. O. Box 868, Pittsburgh 30, Pa.

MP-3050-3

Westinghouse serves these O. E. M. industries

- Air conditioning
- Appliance
- Communications—electronic
- Electric apparatus
- Fan and blower
- Machine tool
- Materials handling
- Panelboard and switchboard
- Prime mover equipment
- Pump and compressor
- Miscellaneous machinery

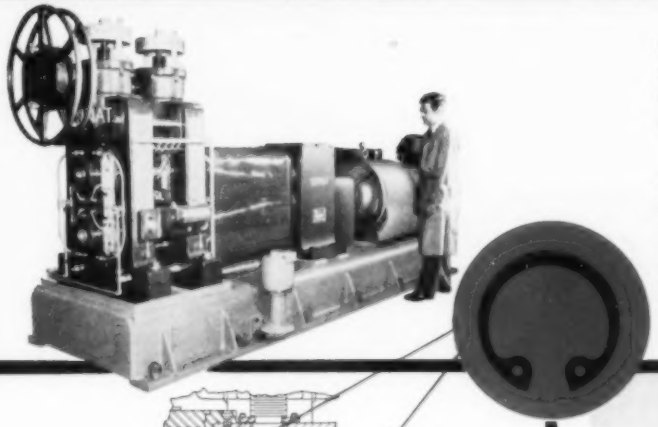
. . . with these components

- Motors—gearmotors
- Adjustable-speed drives
- Gearing
- Controls—relays—circuit breakers
- Semiconductors
- Cypak
- Magamp* magnetic amplifiers—rectifiers
- Heating elements—thermostats
- Transformers
- Instruments
- DYNAC® magnetic braking

*Trade-Mark

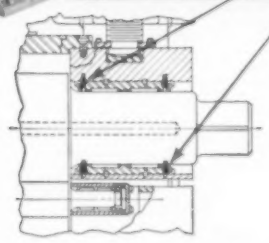
YOU CAN BE SURE... IF IT'S Westinghouse

7-inch Waldes Truarc retaining rings cut costs, speed assembly-disassembly of 2-high/4-high mill

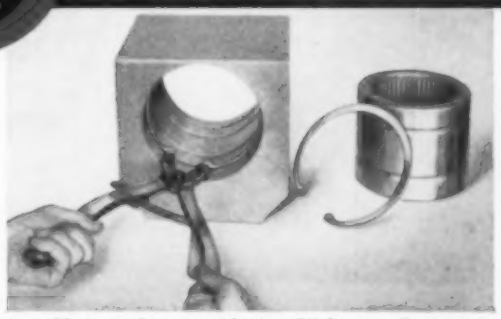


New Model TA-625 2-high/4-high combination rolling mill designed by Stanat Manufacturing Co., Long Island City, N. Y., reduces 2½" ingot to precision-rolled strip as thin as .001".

Waldes Truarc retaining rings help make possible a complete change of work rolls in 20 minutes... solve difficult problems of accuracy control by achieving positive location of bearings to extremely close tolerances. Rings eliminate costly parts and machining, save space, reduce maintenance.



In the assembly illustrated above, 7" Waldes Truarc (Series 5000) retaining rings—three on each roller—are used to position heavy-duty needle bearings in the bearing housing. Smaller rings position bearings in other roller assemblies and retain the shaft of a dual handwheel screwdown. All in all, 18 Waldes Truarc rings are used in the mill. They replace machined shoulders, spacers and lock nuts... eliminate costly threading, other machining operations.



Assembly is simple, even with giant 7" diameter Truarc ring. Special Truarc ratchet pliers grasp the ring securely, ease it into the groove, snap it securely into position. Smaller pliers and various high-speed assembly jigs are available for other rings, permit assembly-disassembly to be performed rapidly even by unskilled labor.

Whatever you make, there's a Waldes Truarc Retaining Ring designed to improve your product... to save you material, machining and labor costs. Quick and easy to assemble and disassemble, they do a better job of holding parts together. Truarc rings are precision-engineered and precision-made, quality controlled from raw material to finished ring.

36 functionally different types... as many as 97 different sizes within a type... 5 metal specifications and 14 different finishes. Truarc rings are available from 90 stocking points throughout the U.S.A. and Canada.

More than 30 engineering-minded factory representatives and 700 field men are available to you on call. Send us your blueprints today... let our Truarc engineers help you solve design, assembly and production problems... without obligation.

For precision internal grooving and undercutting... Waldes Truarc Grooving Tool!

WALDES TRUARC® RETAINING RINGS

©1956 Waldes Kohinoor, Inc., 47-16 Austel Place, L.I.C.1, N.Y.

Waldes Kohinoor, Inc., 47-16 Austel Place, L.I.C. 1, N.Y.
Please send the new supplement No. 1 which brings Truarc Catalog RR 9-52 up to date.
(Please print)

Name _____
Title _____
Company _____
Business Address _____
City _____ *Zone* _____ *State* _____

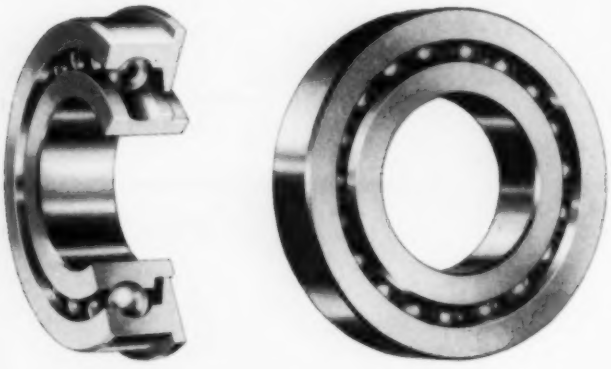
PN079

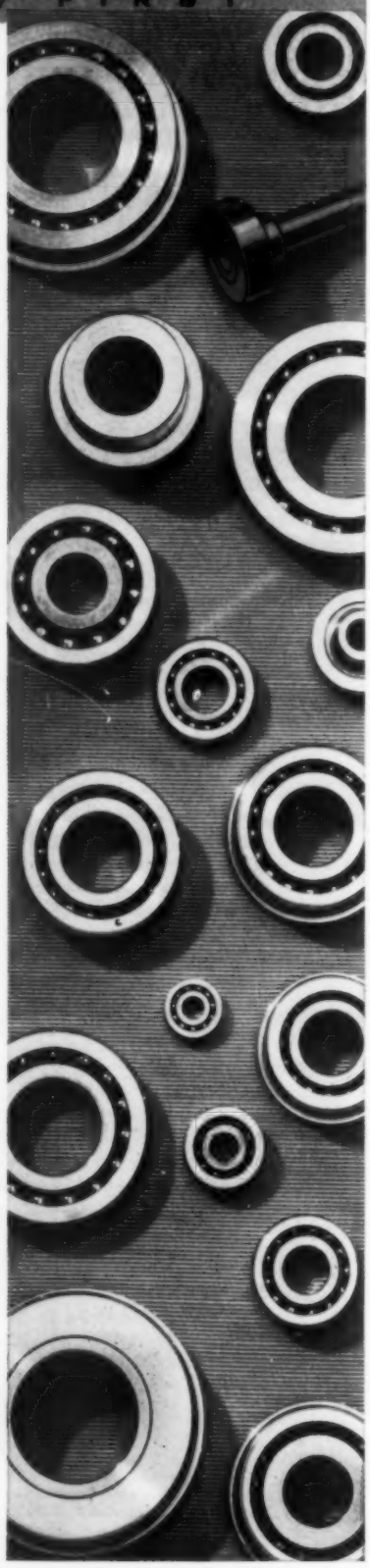
WALDES TRUARC Retaining Rings, Grooving Tools, Pliers, Applicators and Dispensers are protected by one or more of the following U. S. Patents: 2,382,948; 2,411,426; 2,411,761; 2,416,852; 2,420,921; 2,428,341; 2,439,785; 2,441,846; 2,455,165; 2,483,379; 2,483,380; 2,483,383; 2,487,802; 2,487,803; 2,491,306; 2,491,310; 2,509,081; 2,544,631; 2,546,616; 2,547,263; 2,558,704; 2,574,034; 2,577,319; 2,595,787, and other U. S. Patents pending. Equal patent protection established in foreign countries.

ANOTHER HEIM *Unibal* FIRST

HEIM INTRODUCES THE NEWEST IDEA IN BALL BEARINGS

without insertion grooves or inserts





A most unusual, NEW concept in ball bearing design . . .

Here is a commercial ball bearing with solid, unbroken machined inner and outer raceways, yet with a full complement of balls.

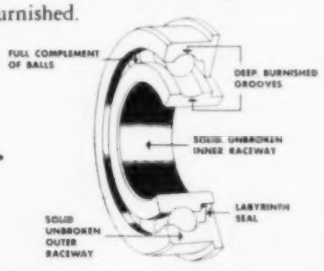
It has deep, burnished ball grooves that are deep carburized and hardened. The revolutionary and radically new method of manufacture permits assembly of these ball bearings in a way that borders on the mysterious and challenges the imagination.

Radial and axial load capacities are increased because of the raceway construction, resulting in longer bearing life.

Unibal Ball Bearings can be furnished in single row, double row and flanged types; to close tolerances on bore and outside diameter; and with controlled radial and axial play.

Close, integral labyrinth seals on one or both sides are another unusual feature, where sealed type bearings are required. Extremely narrow widths and small diameters can be furnished.

NOTE THIS CONSTRUCTION . . .



Special circular with load ratings and dimensions on the new Unibal Ball Bearings is available.

HEIM also makes the Unibal Spherical Bearing Rod End. Send for complete catalog of all Heim bearings. Write direct or see your local bearing distributor.

THE HEIM COMPANY / Fairfield, Connecticut

Wherever your machinery is shipped...

the performance and the name are the same around the world!

FOR YEARS SHELL TELLUS OIL has been top-rated as both a lubricant and a control fluid for complex hydraulic systems. Its ability to combat foaming, oxidation, rust, sludge-formation and wear has earned it nation-wide popularity.

You may be glad to know that the equipment you manufacture can get the same efficient protection in foreign countries. Tellus* Oil is available to your foreign customers from near-by points. It will be the same Tellus Oil that your domestic customers rely upon. Write Shell Oil Company, 50 West 50th St., New York 20, New York, or 100 Bush Street, San Francisco 6, California.

*Trademark

Machinery manufacturers:

Your customers abroad will receive the same Shell Tellus Oil that your domestic customers enjoy. And this same uniformity applies to

SHELL TURBO OIL—gives anti-wear lubrication for utility, industrial and marine turbines

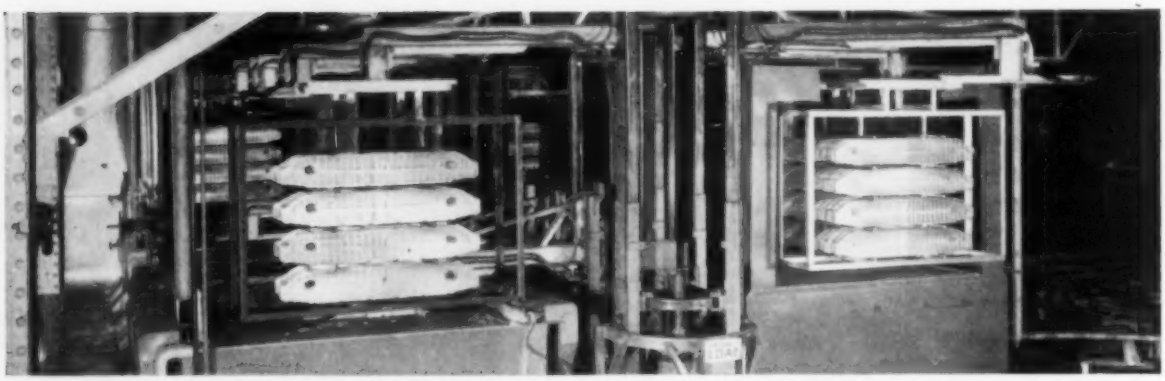
SHELL ALVANIA GREASE—multi-purpose industrial grease, and a complete line of other

SHELL INDUSTRIAL LUBRICANTS

SHELL TELLUS OIL

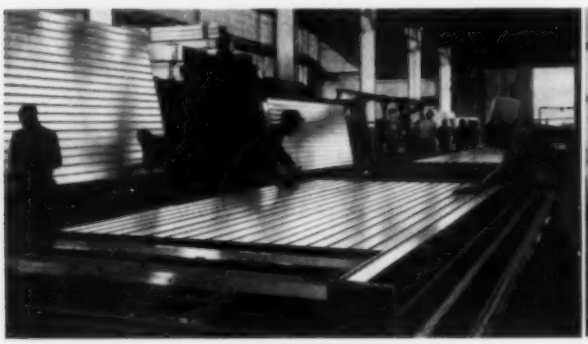
SHELL

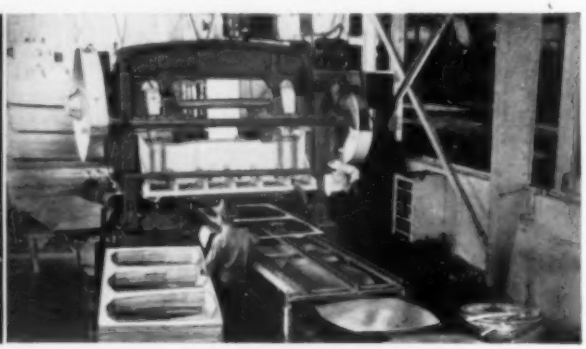
Parts for the products *you design* can be economically fabricated and here are 7



1 Reynolds ADDS TO YOUR CAPACITY WITHOUT INCREASING COSTS

Reynolds great variety of specialized equipment assures you the economy of the equipment best suited to your purpose. This can save you important capital investments in equipment and added plant capacity. The new Reynolds automatic aluminum finishing system above—shown gold anodizing automobile grilles—can finish mixed sizes and types of parts and chemically brighten or anodize them in different colors—and can handle several different jobs at the same time. An automatic coding system establishes the individual finishing specifications for each job.





2 Reynolds CUTS YOUR MATERIAL HANDLING COSTS

Reynolds assembling of the aluminum siding panels for truck subassemblies above is saving money for a truck-trailer manufacturer. Whether you make telephone booths, portable TV cabinets or a host of other products, you'll cut your handling costs by getting parts from Reynolds. Reynolds also takes the problems of scheduling, material supply, labor and machine availability off your hands.

3 Reynolds CUTS YOUR SCRAP LOSS AND HANDLING COSTS

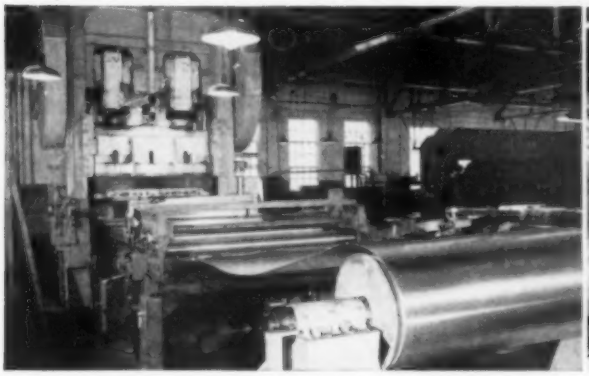
The aluminum blanks on the conveyor are ready to go to an appliance manufacturer. The scrap beside the press is remelted immediately right at the Reynolds plant. Thus Reynolds Aluminum Fabricating Service saves you—the manufacturer—an average of 30% scrap loss and also eliminates costly time and labor scrap handling expense on your part in sorting, storing and shipping.

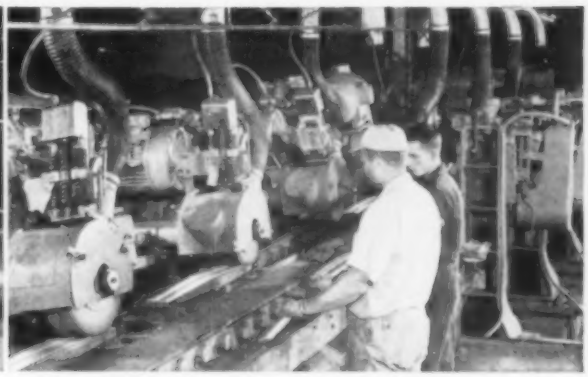
For details on Reynolds fabricating and finishing facilities write for your copy of Reynolds "Complete Facilities" brochure. And for the assistance of Reynolds Styling and Engineering Service, contact your nearest Reynolds Office or write to the address on the facing page.

The Finest Products Made with Aluminum are made with REYNOLDS ALUMINUM

finished by Reynolds

good reasons why





4 **Reynolds REDUCES YOUR RAW MATERIAL INVENTORY**

You get *pounds of parts* instead of pounds of metal when you use Reynolds Aluminum Fabricating Service. Like the manufacturer who will receive the parts in work on these high speed coil fed presses, you too can save by cutting out that costly part of your metal inventory that does not go into finished parts.

5 **Reynolds RELEASES YOUR VALUABLE FLOOR SPACE**

Equipment such as Reynolds new high speed buffing machines above, plus stocks of raw materials, take up valuable floor space. Imagine the space you can save in your plant—space you can put to profitable use—when you rely on Reynolds to produce quality aluminum components for your products.

6 **Reynolds OFFERS YOU DELAYED MATERIAL BILLING**

You receive 100% of your aluminum in finished parts when you use Reynolds Aluminum Fabricating Service. And, as these parts are generally billed after assembly into finished products, no investment is tied up in raw metal. Roll forming machines are but one example of the more than 200 pieces of major fabricating and finishing equipment offered by Reynolds in two plants alone.

7 **Reynolds ELIMINATES YOUR REJECT COSTS**

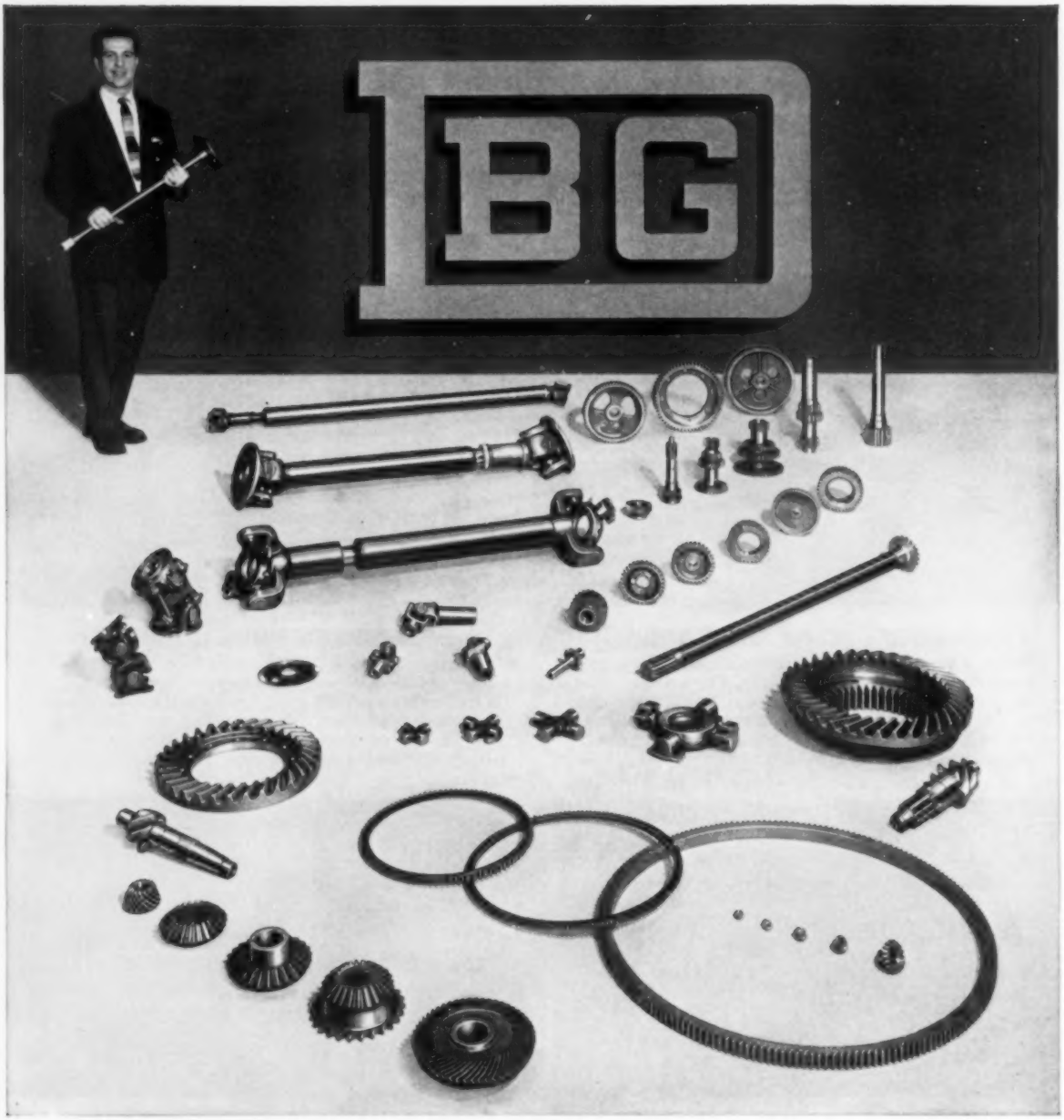
Reynolds Aluminum Fabricating Service does away with your machine and labor production losses and inspection expense in rejects, because you pay only for finished, inspected parts. The conveyor line above, where finished aluminum parts are carefully inspected before packing and shipping, is just one of the many examples of Reynolds quality control from mine to finished part.

See "CIRCUS BOY", Reynolds exciting dramatic series, Sundays, NBC-TV

REYNOLDS ALUMINUM FABRICATING SERVICE

2051 South Ninth Street, Louisville 1, Kentucky

BLANKING • EMBOSSING
STAMPING • DRAWING
RIVETING • FORMING
ROLL SHAPING • TUBE
BENDING • WELDING
BRAZING • FINISHING



The Principle That Builds Better Gears, Joints and Axles

When DBG built their first automotive gear back in 1912, a principle was born: "Build an outstanding product at a competitive cost . . . but never sacrifice quality for price."

Word spread. DBG grew. People who asked us to design or build one product asked us to design and build other types. Result: now, you'll find DBG products in fields as diverse as aviation, automotive, instrument, road building and heavy construction equipment. DBG quality is found in power take-off universal joints and heavy duty drivelines . . . instrument gears and gears for giant off-the-road equipment. The result is a wide range of drivelines, bevels, gears and axles, and *only* a *few* are shown above!

Why not capitalize on this experience? Write or phone *today*.

Drivelines
Bevels
Gears

57A

DETROIT BEVEL GEAR COMPANY

Producers of QUALITY GEARS, AXLES, UNIVERSAL JOINTS

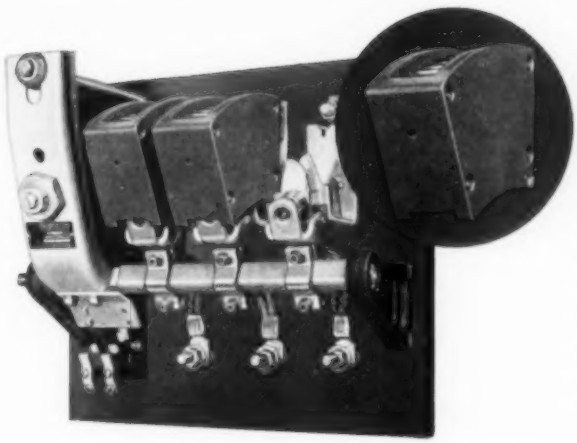
A subsidiary of the Gear Grinding Machine Company, Detroit, Michigan • 8126 Jos. Campau Avenue, Detroit 11, Michigan, TR 2-0200

for fast arc interruption... without blowout coils

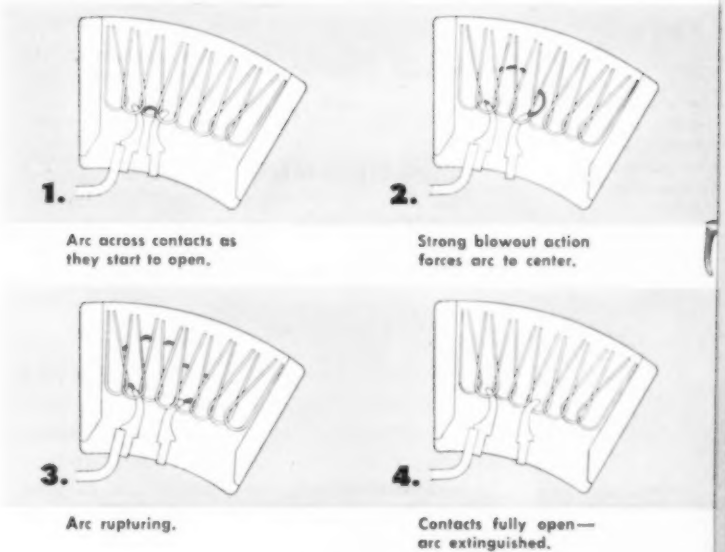
ALLIS-CHALMERS

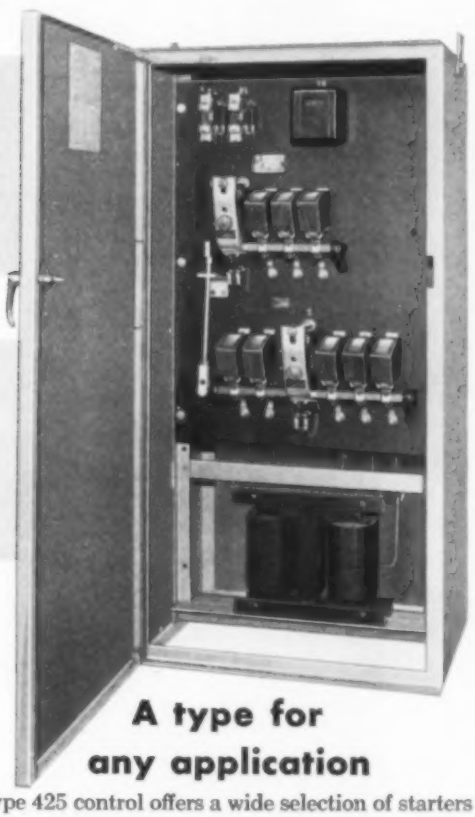
TYPE 425 CONTROL

featuring *ACBO* arc-centering blowout chutes for 50 to 400 hp



The advanced electrical design of Allis-Chalmers Size 4, 5 and 6 control incorporates a modern principle of arc interruption for low voltage, high horsepower applications. The *ACBO* arc chute utilizes principles of magnetic action and thermal convection to center, rupture and extinguish the arc . . . quickly. Fast arc interruption assures maximum contactor efficiency, improves performance — greatly prolongs contact and chute life.





Simplified mechanical design

- Streamlined clapper-type construction eliminates many parts.
- Accessibility simplifies maintenance and inspection.
- Installation is fast and easy . . . sensible enclosure dimensions provide ample wiring space.

A type for any application

Type 425 control offers a wide selection of starters and contactors for any application. For detailed information, call your A-C Control Distributor or your local A-C District Office . . . or write Allis-Chalmers, General Products Division, Milwaukee 1, Wisconsin. Ask for Bulletin 14B8615.

A-C ALLIS-CHALMERS

ACBO is an Allis-Chalmers trademark.

A-5343

ALLIS-CHALMERS

NOW! A Small Machine That Makes Big Prints . . . New Model 300!

It's only 46" wide, yet offers a full 30" printing width! This remarkable low-priced table top machine brings "inside" reproduction within the means of the smallest department or firm, makes an ideal "extra" machine for large companies. Handles every type of reproduction job that bigger, costlier machines do. Operates on 115 volt A.C.

Right Now Is the Time to New and Better Copyflex

NOW! A Faster, Easier-to-Use, Heavy-Volume Machine . . . Model 500!

You'll turn out more work with less operator time and effort with this new, ultra-fast machine. It offers top mechanical speed of 40 f.p.m., 46" printing width, automatic separation, front or rear delivery, automatic stacking, and a host of other advanced features. Its 4,000-watt quartz lamp and synchronized exposure and developer units assure uniformly sharp, clear prints.

Act Now to Save Time and Manpower, Meet Growing Production Boom Demands!

Now is the time to take a good look at your older reproduction equipment. If it's more than a few years old, chances are it's costing you unnecessary time and money. It may well turn out to be a bottleneck in your efforts to meet growing production boom demands.

Compare your equipment with the new, modern Bruning machines shown here. You should be getting the time and manpower savings offered by greater mechanical speeds, faster return of originals, automatic separation, front or rear delivery! You should be benefiting by problem-free installation and operation—no exhaust venting, no plumbing or auxiliary equipment, no installation other than an electrical connection.

If you're not getting these important advantages, then every day you delay getting new, modern Copyflex is costing you time and money. Act now by mailing the coupon below. You'll be glad you did!

NOW! The Speedy, Versatile Helper Your Big Machine Needs . . . New Model 110!

When you need prints of such smaller size originals as specification sheets, check prints, and engineering changes, this handy table top machine turns them out in a jiffy without tying up your big machine. It saves you time, money, and inconvenience. It has a printing width of 11". Makes 8½ x 11 prints for less than 1¢ each for materials. Operates on 115 volt A.C.

Replace Old Equipment with Reproduction Machines!

Now! A Space-Saving, Versatile Big-Volume Machine . . . Model 250!

It takes less than a square yard of floor space, yet offers a printing width of 18½" and a fast mechanical speed of 25 f.p.m. Automatic separation and stacking, one-knob control, and an extra-large feed board simplify and speed operator's work. Operates on 220 volt A.C.

NOW! A Budget-Priced, Heavy-Volume Machine . . . New Model 35!

This low-cost machine gives you all the advantages of big volume savings and speed. It provides a full 46" printing width and up to 30 f.p.m. mechanical speed. One knob controls exposure and development, assures consistently top quality prints. Handles roll stock up to 42" wide quickly and efficiently. Operates on 220 volt A.C.

SEND FOR MORE INFORMATION TODAY!

BRUNING Copyflex

Best Process! Best Machines! Best Selection of Materials!

Offices in 38 Cities of the U. S. and Canada

CHARLES BRUNING COMPANY, INC., CHICAGO

In Canada: Charles Bruning Co. (Canada) Ltd., 105 Church St., Toronto 1, Ont.

Charles Bruning Company, Inc., Dept. 73-O
4700 Montrose Ave., Chicago 41, Illinois

Please send me information on the Copyflex process and the following machines: _____

Name _____ **Title** _____

Company _____

Address _____

City _____ **County** _____ **State** _____

Which Type ADJUSTABLE SPEED DRIVE CONTROL Do You Need? SQUARE D BUILDS BOTH!

Typical application of Adjustable Voltage Drive to large metal spinning lathe in operation at Phoenix Products Company, Milwaukee

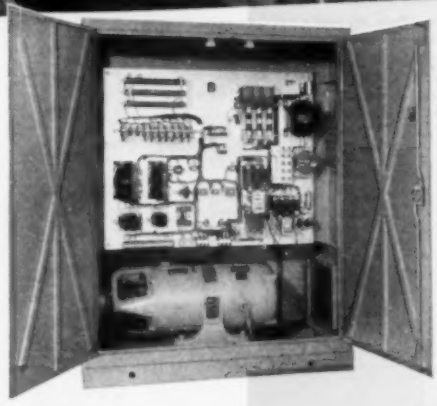
ADJUSTABLE VOLTAGE CONTROL FOR M-G SETS...Through 400 HP

Simplified Circuits with rugged heavy-duty control components.

Easy Maintenance because standard magnetic starters, relays and timers are used in combination with static regulators.

3 Types Available • (*1*) magnetic amplifier exciters (*2*) dry disc exciters (*3*) rotating exciters.

Easy to Adjust because centralized "tune-up" elements are accessible and readily identified.



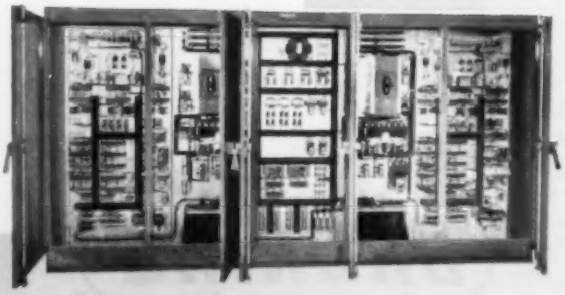
FULLY ELECTRONIC with SIMPLIFIED FAIL-SAFE CIRCUITS THROUGHOUT

Simplified Circuits use less tubes. Fail-safe circuits prevent motor runaways.

Easy Maintenance because sub-panels can be quickly removed and replaced. "Brain" panel senses varying conditions.

Easy to Adjust with only a few, very accessible potentiometers.

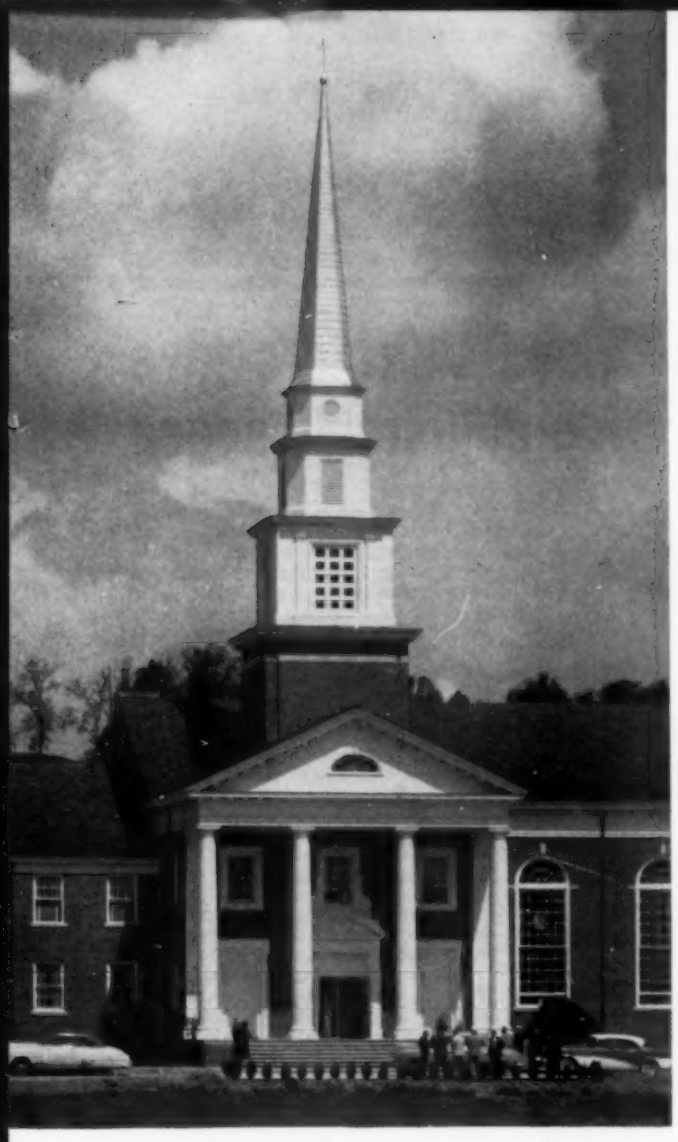
Both types are available in two kinds of construction—standard package and custom-built.



Write for descriptive literature. Address Square D Company, 4041 North Richards St., Milwaukee 12, Wis.

EC&M HEAVY INDUSTRY ELECTRICAL EQUIPMENT...NOW A PART OF THE SQUARE D LINE

SQUARE D COMPANY



NOTHING *can equal Stainless Steel*

in its unique combination of properties

No other design material can match Stainless Steel in its combination of desirable properties: corrosion resistance, strength, hardness, beauty, cleanability and easy fabrication. If you're looking for a reliable source of supply, remember that United States Steel offers you the widest range of types, finishes and sizes.

UNITED STATES STEEL CORPORATION, PITTSBURGH • AMERICAN STEEL & WIRE DIVISION, CLEVELAND
COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO • NATIONAL TUBE DIVISION, PITTSBURGH
TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA.
UNITED STATES STEEL SUPPLY DIVISION, WAREHOUSE DISTRIBUTORS
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

USS STAINLESS STEEL

SHEETS • STRIP • PLATES • BARS • BILLETS
PIPE • TUBES • WIRE • SPECIAL SECTIONS

USS

UNITED STATES STEEL

◀

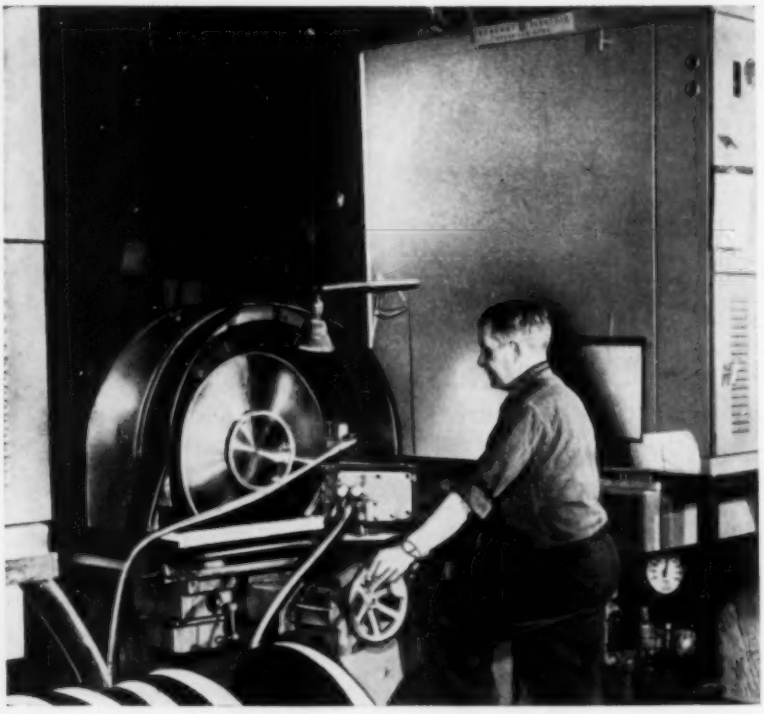
FOR BEAUTY. Stainless Steel shingles in diminishing sizes create a beautiful, gleaming steeple for the State Street Methodist Church in Bristol, Virginia. Architect Allen Dryden, of Kingsport, Tenn., specifies Stainless Steel for jobs like this to assure lasting beauty, protection from weather and freedom from maintenance. This spire is sheathed in Type 302 26-gage Stainless Steel, and the cross is built of Type 302 Stainless bars. Construction details were engineered by Overly Manufacturing Company, Greensburg, Pa., who also fabricated and erected the steeple.

FOR FLEXIBILITY OF DESIGN. In this "Cold-Zone" cooling-storage milk products tank, made by Damrow Brothers Company, Fond du Lac, Wisc., Type 304 10-gage Stainless Steel was used for the smooth, easy-to-clean inner wall. Again Stainless Steel—this time Type 304 16-gage—was used for the dimpled outer wall which is stave-welded to the inner shell. This unusual design of dimple size and arrangement gives proper baffling and velocity to the refrigerant as it passes through the cooling area. Stainless Steel provides greater sanitation, durability, long life, strength and—the flexibility necessary to make this design possible.

FOR DURABILITY. The Master Combination Padlock, designed for school locker room use and built by Master Lock Company, Milwaukee, Wisconsin, features a double-case construction—with Type 430 Stainless Steel used for the outer case. This Stainless Steel design makes it one of the strongest padlocks available. In addition to increasing the lock's durability, Stainless Steel also adds to its sales appeal and to its resistance to the corrosive atmospheres of damp locker rooms. The springs, too, are made from USS Stainless Steel—Type 304 Ameroxide coated wire.

Designer's

Packaged, easy-to-install Speed Variators give machines you build wide-range adjustable speed



On milling machines, lathes, boring mills, and other machine tools, you can build in improved production continuity and greater versatility of product output with a General Electric packaged Speed Variator. This system-engineered adjustable-speed drive provides closely controlled speeds and a wide range of speed adjustment.

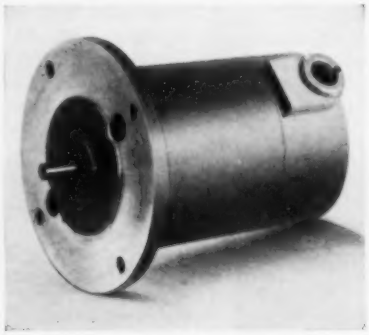
Pre-engineered, assembled, packaged and tested to your specifications before it leaves the factory, this G-E drive features easy, low-cost installation. Just set the components in place—d-c drive motor, space-saving power unit, and operator's control—and connect the load. Power unit and control can be located wherever convenient.

A wide selection of available ratings and speed ranges in the basic unit meets most adjustable-speed needs. To match your particular needs still more closely, other features can be added, including dynamic braking, jogging, reversing, and regulation (amplistat, electronic, or amplidyne). See Bulletin GEA-6127.

◀**CONSTANT CUTTING SPEED** is provided by this General Electric Speed Variator, driving lathe for machining jet turbine wheels.

New small-diameter tachometer generators measure and regulate motor speeds

D-c tachometer generator



A-c tachometer generator

In speed-regulated drive schemes such as those used for automated process machinery, speeds from 100 to 5000 rpm can be accurately measured with General Electric's new d-c tachometer generators, used with suitable instrumentation. These lightweight (less than 6½ lbs) units supply a signal source needed to maintain speed regulation.

Also available are a-c tachometer generators weighing less than 4 lbs. These units, of 4-pole construction, serve speed ranges from 400 to 5000 rpm.

Both units are less than 3½ in. in diameter and totally enclosed. See Bulletin GEC-1405.

GENERAL ELECTRIC

Digest

PRODUCT HIGHLIGHTS

General Electric numerical positioning control systems increase machine-tool productivity and accuracy, cut waste

With General Electric numerical positioning control designed into the machine tools you build, your customer can:

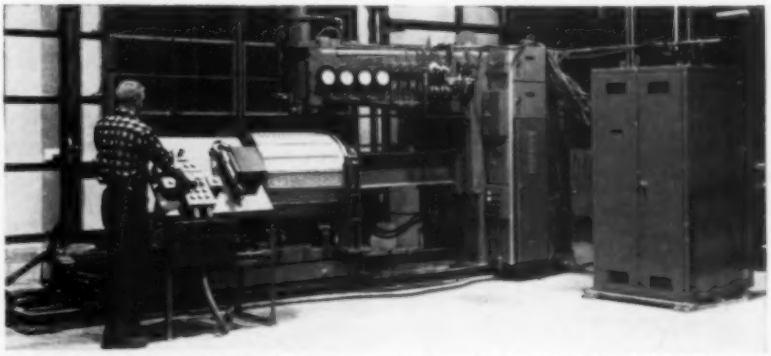
Raise machine productivity by eliminating time-consuming making and setting of templates, allowing more time for productive work;

Raise machine accuracy because NPC can maintain accuracies up to ±.0005 in. automatically, without operator judgement;

Reduce spoilage because NPC automatically directs the machine and removes the factor of human error;

Raise machine speed since NPC can be programmed to utilize optimum machine horsepower feeds and speeds prechosen by engineer.

Easily apply it, where point to point positioning is required, to turret-type punch presses, step turning lathes, shears, riveting, placement, milling, boring, and drilling machines.



FIRST USE OF PRE-PUNCHED TAPE in G-E numerical positioning control is on this resistance welding machine made by National Electric Welding Machines Co. It makes 1650 spot welds on automatically positioned liner of jet engine afterburner for General Electric's Small Aircraft Engine Department. Metal cabinet (r.) houses positioning control.

With this method for automatic programming of machine cycles, the operator merely pushes start button and machine automatically runs through sequence of operations required. Speed, accuracy, and length of motion can be individually selected for each application. See Bulletin GEA-6594.

New coolant-pump motor has long bearing life

For long bearing life, this new General Electric fractional-hp motor has large grease reservoirs that hold a supply of a new, moisture-resistant grease that lasts for 10 years of normal motor operation. Specially designed for machine-tool coolant pumps, the motor is totally enclosed to minimize the danger of damage from entrance of metal and dirt particles, provide operating dependability. Unified insulation system permits extra-long motor life. Mounting can be either horizontal or vertical, direct-coupled to your pump. Ratings are ¼ to ¾ hp. See Bulletin GEA-6582.

Machine-tool load indicator applies to any a-c motor

A continuous visual check on **all** a-c motors—in any horsepower, voltage or commercial frequency—is provided by General Electric load indicators. Standardizing on one indicating instrument in your machine-tool designs gives you availability, stocking and price benefits.

Easy-to-read color scale shows safe, caution and danger zones. Indicator is calibrated in per cent of motor full load current; no need to know actual current. Wide variety of sizes includes 4½-in. type with 3-in. scale (shown) 3½-in. type with 2-in. scale, and concentric-scale types in 4½-in. and 8¾-in. sizes. See Bulletin GEC-368.

General Electric Co., Apparatus Sales Division, Section A668-135, Schenectady 5, N. Y.

Please send me the following bulletins:

√ for reference purposes	X for immediate project
☐ GEA-6127 Packaged speed variator	☐ GEA-6582 Coolant pump motor
☐ GEA-6594 Numerical positioning control	☐ GEC-1405 Tachometer Generators
☐ GEC-368 Panel Instruments	

Name _____ Company _____

City _____ State _____

FENWAL'S THERMOSTATS NOW CIGARETTE SIZE

Some Units Smaller Still

Take Little More Room Than Sugar Lump

ASHLAND, MASS. — If you want to control temperatures in tight spots, you should see Fenwal. Fenwal has cut the size of thermostats way down.

You can fit one of their Midget THERMOSWITCH units anywhere a cigarette will fit. And, if you're working with even less space, one of their Miniature THERMOSWITCH units is what you're looking for. The Miniatures are little bigger than a lump of sugar, and some are even smaller.

The Midgets and Miniatures use the same unique principle used in Fenwal's bigger THERMOSWITCH controls. They use it with the same high degree of success.

The principle of all Differential Expansion THERMOSWITCH units, large or small, is this: a single metal shell expands or contracts with temperature changes, making or breaking totally enclosed electrical contacts.

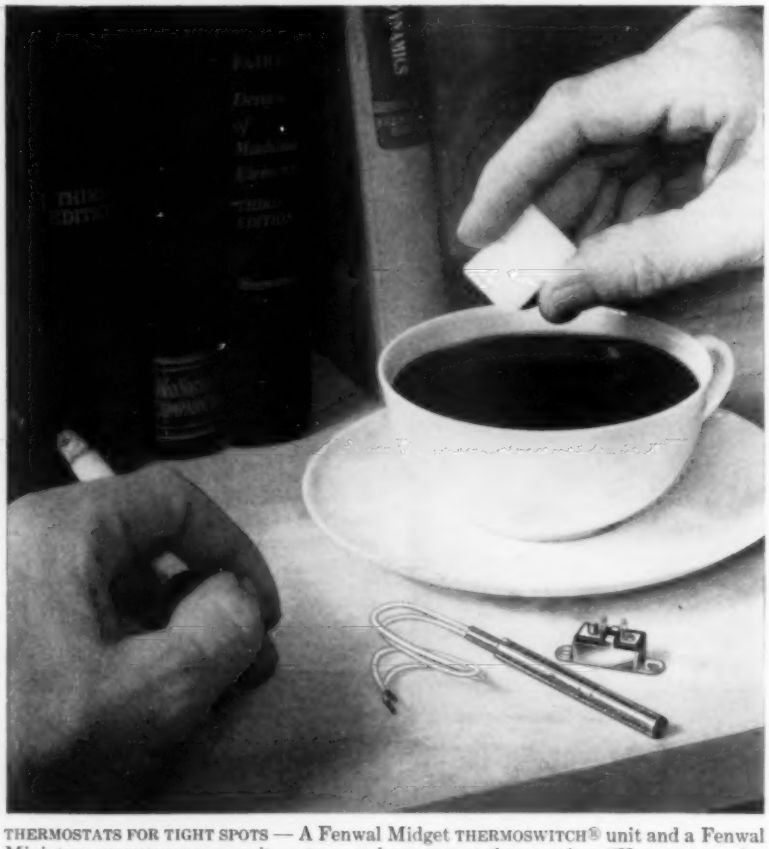
The smallness of the Midget and Miniature units does not deprive them of any of the performance characteristics that have made larger THERMOSWITCH units famous. They have THERMOSWITCH ruggedness, THERMOSWITCH accuracy, and reasonable THERMOSWITCH prices.

Temperature range of the Midget series: −50°F to 500°F. Range of the still smaller Miniature series: −20°F to 275°F.

Midgets and Miniatures, all in stainless steel, come in a variety of mountings. Hermetic sealing is also available.

These Fenwal THERMOSWITCH units are precision-engineered to give optimum temperature control with minimum-sized devices. They remain accurate under the most severe operating conditions.

You should have details on this advance in temperature control at your fingertips. Write for information to **Fenwal Incorporated, 29 Pleasant Street, Ashland, Massachusetts.**



THERMOSTATS FOR TIGHT SPOTS — A Fenwal Midget THERMOSWITCH® unit and a Fenwal Miniature THERMOSWITCH unit — two good answers to the question, "How can you install an accurate, reliable thermostat where there's almost no room?" Actual sizes of these particular models — ¼" x 2 25/32" for the Midget; 1" x ½" for the Miniature.

Fenwal

CONTROLS TEMPERATURE
...PRECISELY

US RUBBER **PowerGrip** "TIMING" BELTS

"Here's how to sharpen the brains of memory machines,"

says Plant Engineer **"GRIP" POWERS**

SCHEMATIC OF U.S. POWERGRIP "TIMING" BELT DRIVE
ON BOESCH TOROID WINDER (MODEL SM-C)
(A) ⅙ hp motor pulley—3450 rpm, 1¾" diam.
(B) jack shaft pulley—2156 rpm, 2¹³⁄₁₆" diam.
(C) jack shaft pulley—2156 rpm, 1¾" diam.
(D) grooved idler—fixed, 1½" diam.
(E) spring loaded idler—1½" diam. Pivot arm, attached to spring, compensates for manufacturing tolerances and travel of (F).
(F) spindle head pulley—3800 rpm, 1½" diam. Pulley can be moved 1" in near-flat arc, to set before winding toroid core.
Because of very short centers, small pulley diameters, high speeds and the need for precise control, Boesch selected PowerGrip drives. They have simplified the machine, made it more compact, and more than doubled the life of the drive.
1"
7"
3"
(TB)
(TB)
7"
(A)
(B)
(C)
(D)
(E)
(F)

The "brains" of electronic memory machines are centered in toroids—tiny, doughnut-shaped coils of thousands of turns of tightly wound wire. Winding these toroids requires the utmost precision. That's why Boesch Mfg. Co. (Danbury, Conn.), a leading maker of toroid winders, uses U.S. PowerGrip "Timing"® Belts on their power transmission drives.

U.S. PowerGrip "Timing" Belts have an efficiency of close to 100%. The belts need no lubrication, no maintenance, are more accurate and quieter than drives formerly used and far safer to both operator and machine.

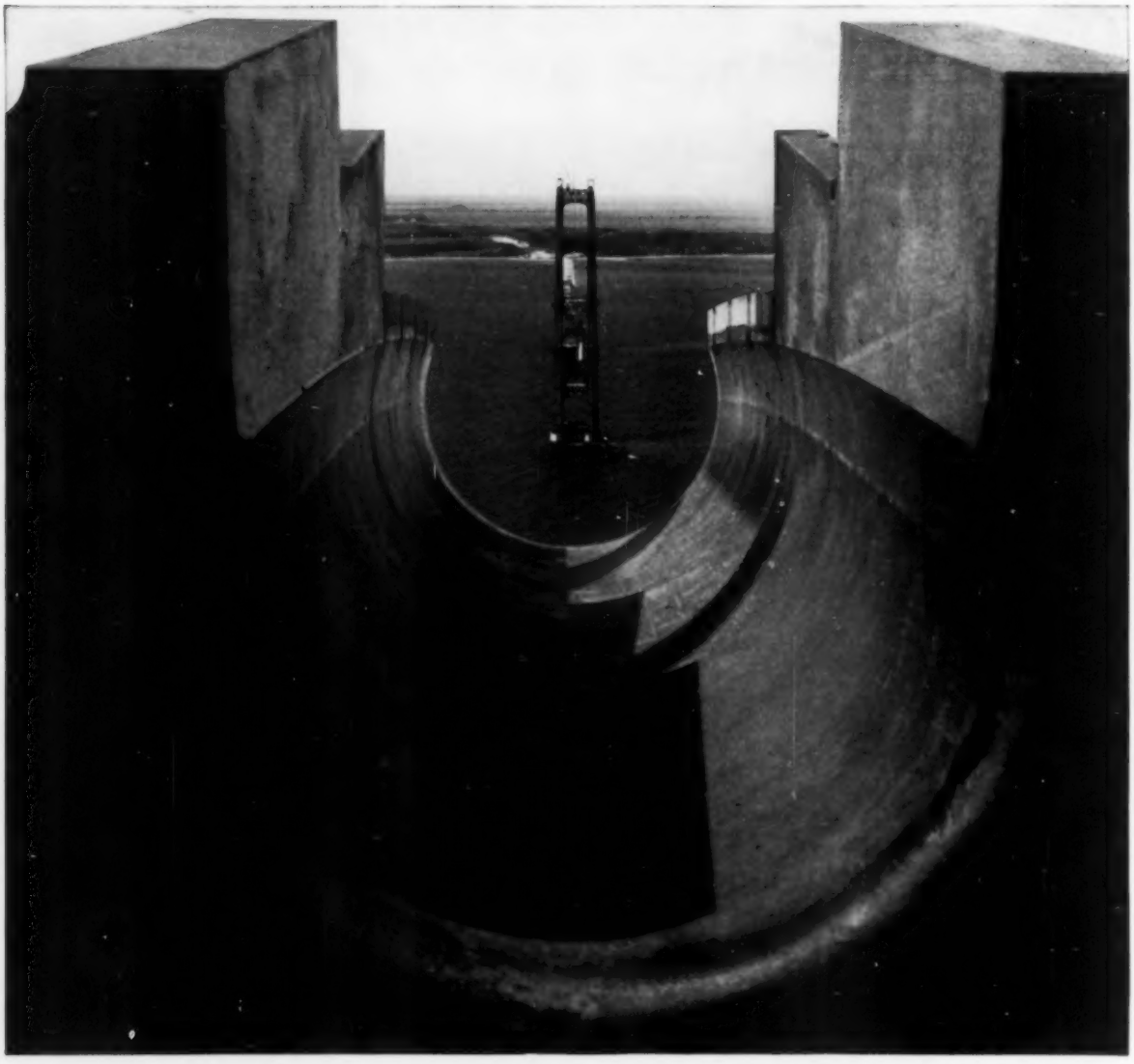
Says the chief engineer of Boesch: "We also use U.S. PowerGrip on our toroidal tape winders and bobbin winding machines. Our engineers and 'U.S.' engineers work hand in hand on *all* our wind-up problems involving power transmission."

A complete line of PowerGrip "Timing" Belt drives—plus expert power transmission engineering assistance—is obtainable at any of the 28 "U.S." District Sales Offices, at selected distributors, or write U.S. Rubber, Mechanical Goods Div., Rockefeller Center, New York 20, N.Y. In Canada: Dominion Rubber Co. Ltd.

US RUBBER **Mechanical Goods Division**

United States Rubber

SEE THINGS YOU NEVER SAW BEFORE. VISIT U.S. RUBBER'S NEW EXHIBIT HALL, ROCKEFELLER CENTER, N.Y.



This 35-ton cast steel tower saddle 522 feet atop one of the two suspension towers provides the framework for this dramatic view. It is one of four such castings which will hold the 24-inch cables supporting the main superstructure of the bridge. Blaw-Knox steel castings are helping to support the superstructures of major bridges crossing practically every principal river or waterway throughout the country, including such recently completed bridges as the Tappan Zee over the Hudson, and the Edgley-Florence spanning the Delaware.

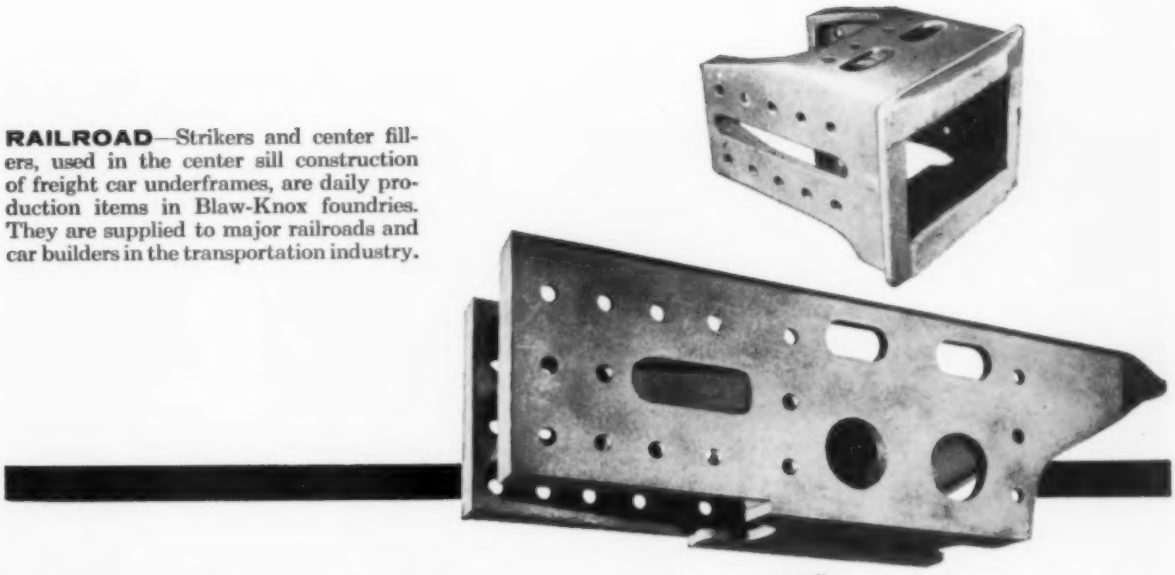
BLAW-KNOX produces heavy duty steel castings for world's longest suspension bridge

Blaw-Knox heavy duty steel castings are playing a key role in the new, 5-mile-long Mackinac Straits Bridge. By providing the great strength and durability necessary for a structure of this size, Blaw-Knox steel castings helped to achieve the engineering goals set for the project.

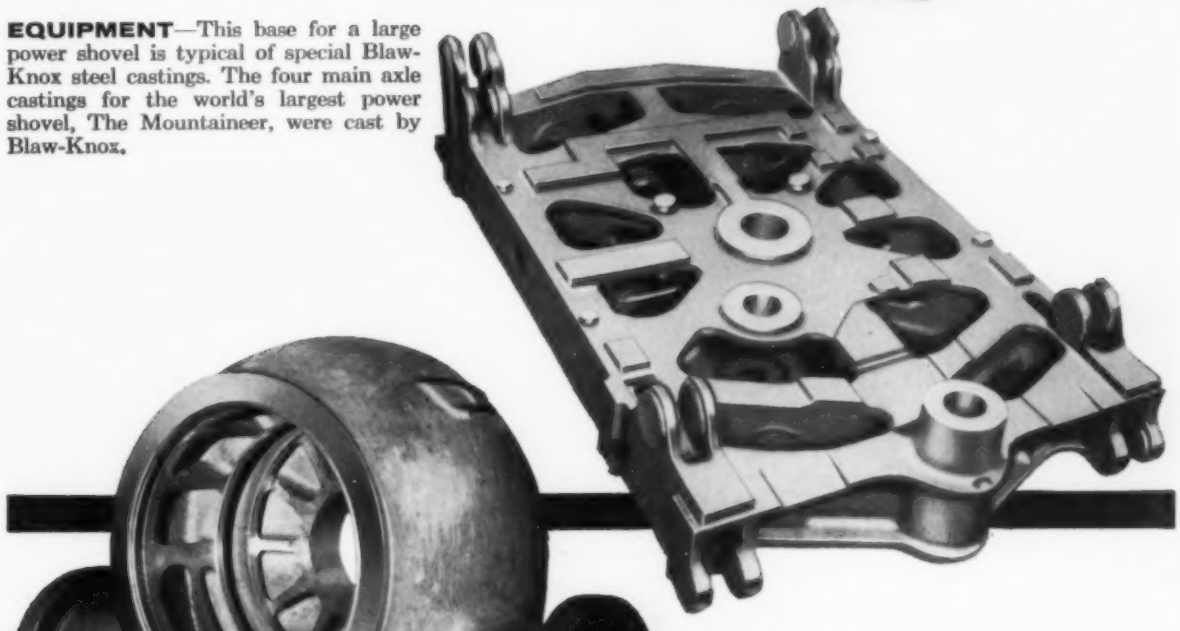
The Mackinac Straits Bridge is an example of how Blaw-Knox steel castings serve men who design and build throughout industry. You will find specially designed Blaw-Knox heavy duty steel castings at work in almost every industry—Rolling Mill and Steel Plant, Railroad, Oil and Gas Field, Metalworking, Hydro-Electric Power Plant, Power Shovel, Electrical Machinery, Chemical, Rubber, Cement, Crushing Machinery and many others.

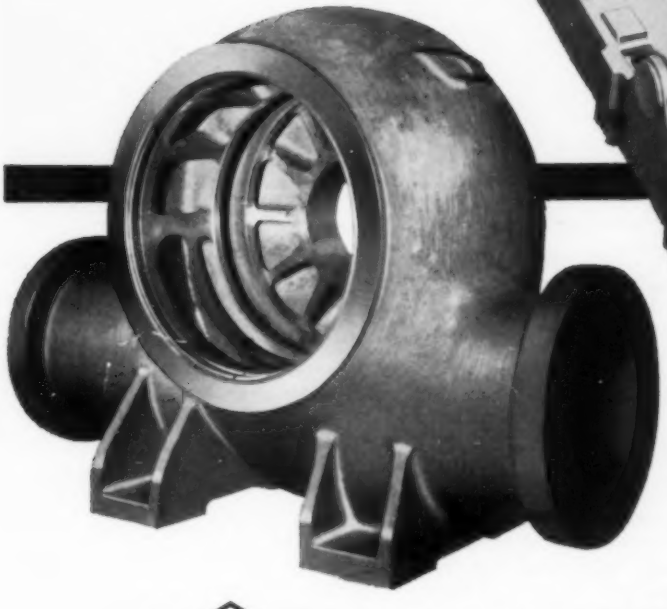
Modern casting techniques coupled with the skill of experienced foundrymen help Blaw-Knox deliver the highest quality castings at the lowest practical cost. A Blaw-Knox castings engineer will be glad to review the specific requirements of your products.

RAILROAD—Strikers and center fillers, used in the center sill construction of freight car underframes, are daily production items in Blaw-Knox foundries. They are supplied to major railroads and car builders in the transportation industry.



EQUIPMENT—This base for a large power shovel is typical of special Blaw-Knox steel castings. The four main axle castings for the world's largest power shovel, The Mountaineer, were cast by Blaw-Knox.





COMPRESSOR—Items like this intricate 20,000 lb. housing (testing pressure 1800 p.s.i. —working pressure 1500 p.s.i.) for a Pipe Line Booster Compressor are regular production items in Blaw-Knox plants which are strategically located in the Pittsburgh and Chicago industrial areas.

BLAW-KNOX

BLAW-KNOX COMPANY

Foundry and Mill Machinery Division

Blaw-Knox Building • 300 Sixth Avenue

Pittsburgh 22, Pennsylvania

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Simplifying the assembly line

A 3M adhesive is helping to create 50 shelves per hour right before your eyes. By bonding parts instantly, EC-1357 simplifies this assembly line to just four fast operations.

One worker puts metal frames and fiberboard sheets on a conveyor moving 9 feet per minute. The second sprays EC-1357 on both as they pass by. The third positions the boards on the frames. They pass under a pressure roller and the bond is complete. There are no extra fastening steps.

Instantly EC-1357 bonds board to frame so strongly that the fiberboard will delaminate if you try to remove it. A fourth man installs molding. The shelves are ready to ship immediately.

Hundreds of other 3M adhesives serve industry in a thousand varied uses.

SEE WHAT ADHESIVES CAN DO FOR YOU!

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DOW CORNING CORPORATION

Silicone News

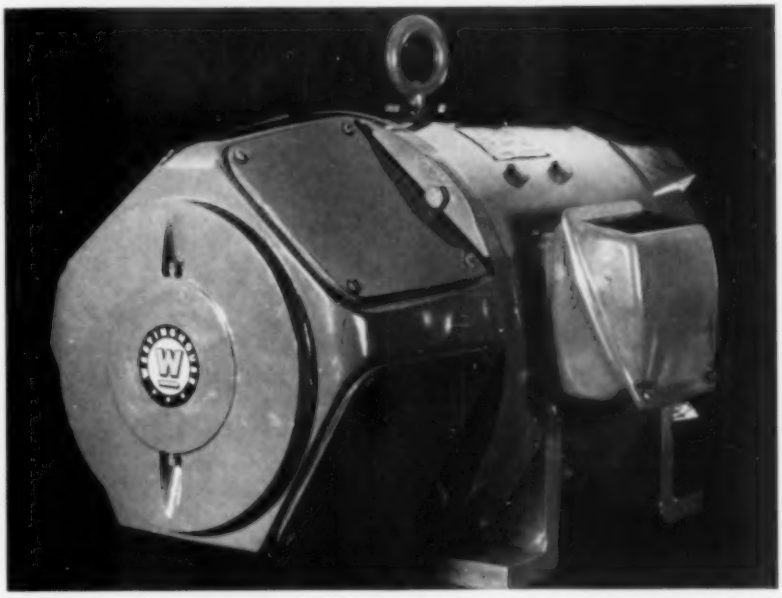
FOR DESIGN ENGINEERS No. 40

Silicone-Glass Heat Dam Combines Thermal Insulation, High Strength

Designers looking for a strong, lightweight, vibration-resistant material that will also serve as a thermal insulator or "heat dam" are finding the answer in silicone bonded glass laminates. A typical application is the generator wiring cap used successfully on one of the more popular jet engines.

The stamped metal covers previously used were notorious conductors of heat and none could long withstand the high-frequency, low-amplitude vibration

characteristic of jet engines. Maintenance and replacement costs were abnormally high until the engine manufacturer replaced the metal covers with caps made from silicone-glass laminate. (*Cont. Pg. 2*)



WESTINGHOUSE INTRODUCES STANDARD LINE OF SILICONE INSULATED D-C MOTORS

While most leading manufacturers of electrical equipment build silicone insulated units for special purposes, now for the first time Westinghouse's new Life Line "H" series offers the advantages of silicone insulation in standard "off the shelf" d-c motors and generators.

Dow Corning Silicones have been used in combining a high temperature insulating system with complements of copper and iron equal to those used in conventional Class B machines. As a result, these new motors and generators rated at Class B temperatures have at least 10 times longer insulation life.

In addition, Dow Corning silicones help provide extra protection against emergency overloads and abnormal ambients to reduce motor maintenance. Insulation is no longer a limiting factor to motor life. Already in production, the new dc motors span ratings from 1 to 150 hp: the dc generators are rated from ¾ to 100 kilowatts.

Life Line "H" equipment is designed to be especially useful for automated processing where insulation failure in one unit may shut down an entire assembly line throw-

(*Cont. Pg. 2*)

Silicone Fluids Provide More Uniform Vibration Damping

For reliable and uniform vibration damping, there's no more practical viscous medium than Dow Corning 200 silicone fluids. With their inherent thermal stability, these semi-inorganic fluids maintain near constant viscosity over exceptionally wide ranges of temperature. Here's how the Sesco Engineering Division of the Haines Gauge Company utilized the advantages of a Dow Corning 200 Fluid to engineer a smaller and lighter-weight vibration damper for use in aircraft.

This miniature damper gives accurate, reliable service at temperatures ranging from —60 to over 160 F. Because the use of Dow Corning 200 Fluid as the damping medium eliminates the need for a mechanical compensating device, the compactly designed unit weighs only 9 ounces filled.

It effectively smooths out unwanted vibration or "hunting"... and can be regulated to allow any desired amount of vibration in a system that is required to oscillate.

Ball-bearing equipped for minimum friction and sealed against atmospheric effects, the Sesco unit operates efficiently in any position. Special models for extremely low temperature use are equipped with seals and diaphragms made from Silastic*, the Dow Corning silicone rubber. ***No. 406***

*T.M. REG. U.S. PAT. OFF.

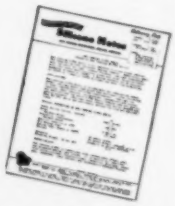
FOR DATA RELATING TO THESE ARTICLES, CIRCLE REFERENCE NUMBER IN COUPON ON NEXT PAGE

MORE

DOW CORNING CORPORATION

Silicone News

DOW CORNING PUBLICATIONS ON NEW DEVELOPMENTS AND TECHNICAL DATA . . . .



Solventless Silicone Impregnating Resins now commercially available for electrical and electronic equipment, are free-flowing, can be blended, and have good pot life. On curing, these silicone encapsulating resins set to a solid mass having good electrical and physical properties; and retain such properties that a service life of 10 years at 400 F is indicated. *No. 410*

Silicone Insulated Motors Last Longer—Cost Less A new brochure bears out this fact with numerous case histories of motors operated for years under adverse conditions in many different industries. An illustrated booklet, it's sure to suggest ways in which you can use silicone insulation to obtain low-cost protection against the effects of overloads, high ambient temperatures, rapid reversing, moisture, and corrosion. *No. 411*

"Rubber From Rock," a new color-sound movie, explains how Silastic, the Dow Corning silicone rubber, is manufactured from quartzite. Demonstrates why parts fabricated from Silastic retain rubber-like properties from —130 to over 500 F in a wide variety of military and industrial applications. Also covers uses for Silastic as a dielectric in electronic and electrical equipment. To arrange for a showing of "Rubber From Rock" in your plant, circle ..... *No. 412*

Silastic 916, the first silicone rubber available that combines high strength with thermal stability, is serviceable from —130 to 500 F, has good electrical properties, and is easy to compound and process. *No. 413*

Dow Corning Silicone Lubricants, including oils and greases, are described in a new, illustrated 8-page brochure that gives their properties, lists their applications, and cites factors which contribute to obtaining longer life. *No. 414*

Parts and components made with Dow Corning Silicone Molding Compounds are lightweight, show excellent resistance to heat, and have good structural and electrical properties. Used as brush holders, collector rings, terminal boards, multiple lead connectors, heat dams for turbine driven alternator bearings, and aircraft brake shoe backing. *No. 415*

RELIABILITY OF "SNARK" MISSILE INSTRUMENTS ASSURED BY SILICONE RUBBER ENCAPSULATION

Engineers at Northrop Aviation take no chances on the performance of intricate high impedance circuits in the "Snark" guided missile, the F-89 Interceptor and other Northrop projects. They virtually "seal in" top performance by completely encapsulating the brains of these units in Silastic* RTV.

A new, easy-to-apply silicone dielectric that vulcanizes into a rubbery solid at room temperatures, Silastic RTV provides positive protection for even the most delicate electronic components. All panels containing resistors, capacitors, transistors and other recording and transmitting gear are embedded in this Dow Corning silicone rubber. According to Northrop engineers, a single coating—

- provides an effective cushion against vibration
- assures maximum moisture resistance
- improves electrical properties, especially surface resistivity
- protects assemblies against rough handling
- may be applied with a caulking gun

Another important advantage of using Silastic RTV in this application is the ease of inspecting or replacing individual components after assembly.

The silicone rubber "skin" is simply slit open to expose the component. Such openings are easily patched with more Silastic RTV.

Silastic RTV ranges from a heavy putty to a fluid-like consistency. It attains optimum physical and dielectric properties in 4 to 7 days. *No. 407*

*T.M. REG. U.S. PAT. OFF.

WESTINGHOUSE MOTORS *(continued)*

ing production schedules and costs way out of line.

The extra overload capacity provided by the silicone insulation system makes these motors ideal for conveyor, pump, blower and processing motors in mines; for drive motors in the glass, machine tool, paper and metals industries; for conveyor drive motors in material handling and many other processing industries.

The use of silicones in this complete line of standard motors within NEMA ratings is a big step forward in the accelerating trend toward more extensive use of silicone insulation systems. *No. 408*

"HEAT DAM" *(continued)*

Not only do the new silicone-glass caps afford better protection for the wiring at unusually high ambients, but the laminate actually has a higher strength-to-weight ratio than many light metals at elevated temperatures.

Bonded with Dow Corning silicone resins, the laminated glass caps are fabricated by Joclin Manufacturing Company, North Haven, Conn. They are supplied in various thicknesses ranging from 7 to 14 plys and maintain their complex, multiplane configuration perfectly despite exposure to severe vibration at operating temperatures as high as 500 F. *No. 409*

Dow Corning Corporation, Dept. 8619, Midland, Michigan

Please send me: 406 407 408 409 410 411 412 413 414 415

NAME _____

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HERE IT IS!

A Complete Westinghouse *Leadership Line* of Military-Approved Insulating and Fungicidal Varnishes for Original Equipment Manufacturers and Repair Shops.

MIL-V-1137A—INSULATING

GRADE	TYPE	MILITARY DESIGNATION
B-161	Clear Baking	Grade CB, Type M
B-163-N	Clear Baking	Grade CB, Type M*
B-166-1	Clear Baking	Grade CB, Type M
B-222-N	Clear Air Drying	Grade CA, Type M*
B-340-N	Black Baking	Grade BB, Type M*
B-451-N	Black Air Drying	Grade BA, Type M

*Also approved for Type AN

MIL-V-173A—FUNGICIDAL

B-219-F	Clear Air Drying	Type II
B-220-F	Clear Air Drying	Type I

YOU CAN BE SURE...IF IT'S

Westinghouse

Whether you're designing, manufacturing, or repairing military electrical apparatus, or whether you simply need quality insulating or fungicidal varnishes or enamels for critical applications, you can't do better than the Westinghouse *Leadership Line* of insulation materials, *field proven* in over 100 million applications!

The chart at left shows some of these remarkable products, approved by the U. S. Navy. For complete information, call your nearest Westinghouse branch or write for your free copy of the 8-page *Leadership Line Catalog* of insulating materials. Just fill out the coupon below. J-06659

PE-7-57

Westinghouse Electric Corporation
Benolite Plant
Manor, Pennsylvania

Please send free copy of *Leadership Line Catalog*.

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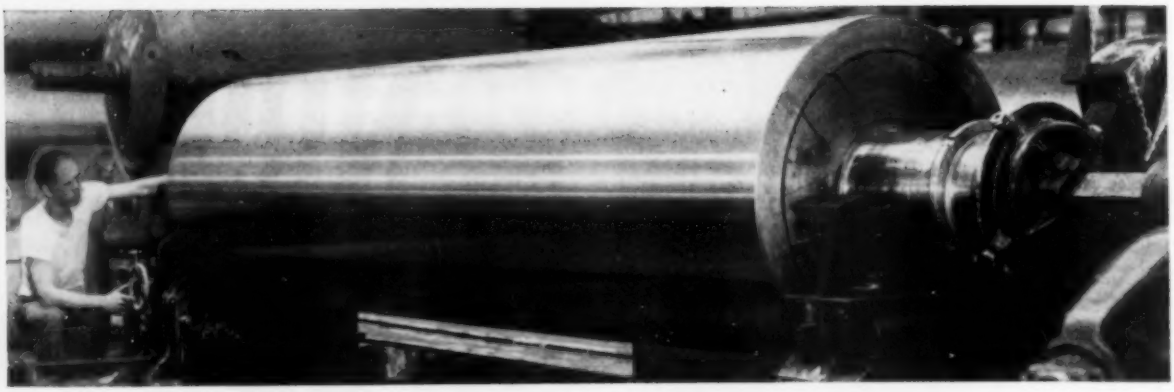
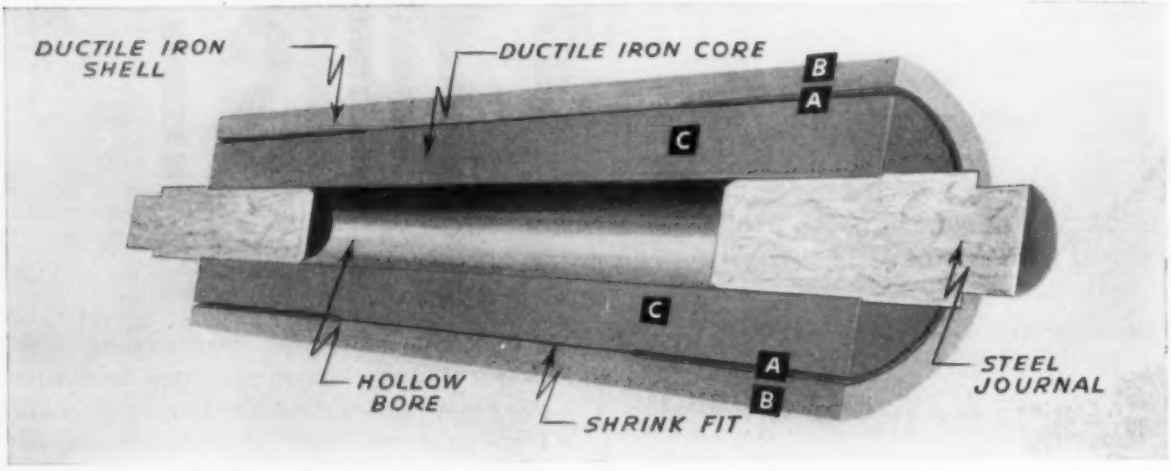


Unusual roll is built without a crown...



Unique design based on high rigidity of ductile cast iron

"Crowning"—designing paper machine rolls with a midriff bulge – compensates for deflection, and helps maintain uniform "nip" pressure between a pair of rolls. But crowning requires costly machining operations and reduces the life of felt roll covers.

To eliminate this problem, Black-Clawson engineers took advantage of the high rigidity of ductile iron – it has a modulus of 24 million. That means it's stiff enough to resist deflection even under heavy loads.

In the crownless press roll shown above, the stiff ductile iron core supports the "nip" load plus the entire roll weight. The open space at (A) allows the core to deflect while the working face of the roll (B) remains almost perfectly flat – within .003 inch. Standard crowned rolls vary from zero to as much as .015 inch through the working range of the "nip" load.

Ductile iron also has the fatigue resistance to withstand the continuously alternating stresses produced at (C) as the roll rotates.

Ductile irons (there are 7 types available commercially) create new design opportunities by combining cast iron's *process* advantages with many of steel's *product* advantages: excellent castability and machinability *plus* high strength, wear resistance, and rigidity without brittleness.

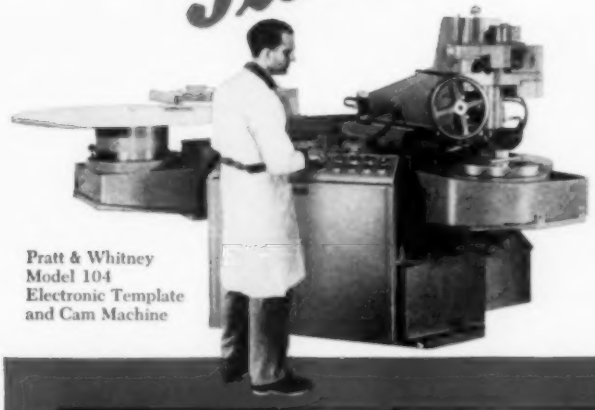
"DUCTILE IRON, THE CAST IRON THAT CAN BE BENT!" contains useful data on ductile irons . . . along with examples of products and processes improved with these unusual, economical metals. If you'd like a copy, just write.

ductile iron . . . the cast iron that can be twisted and bent

The INTERNATIONAL NICKEL COMPANY, Inc.
67 Wall Street, New York 5, N. Y.

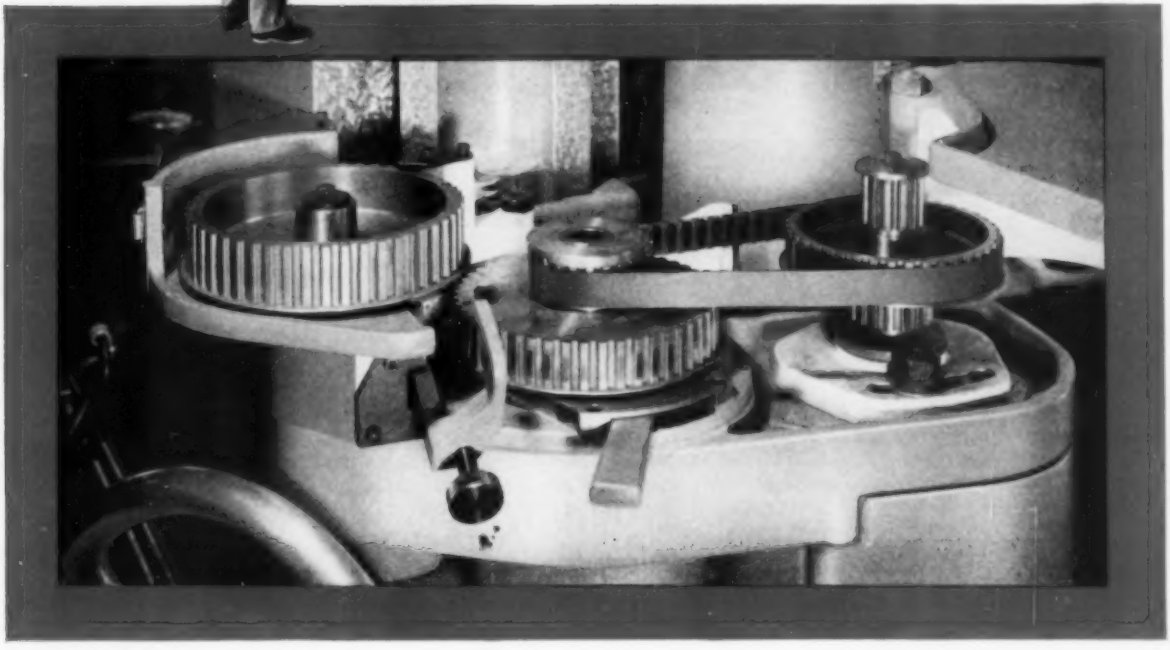
Gilmer "TIMING" BELT DRIVES

give PRATT & WHITNEY vibrationless spindle operation at 48 to 11,500 rpm.



Pratt & Whitney
Model 104
Electronic Template
and Cam Machine

HERE is a modern miracle of machine design: an electronically controlled machine tool that works directly from a *drawing* to produce finished metal parts . . . without the need for costly master formers. Its non-contacting, spark-gap tracer disc automatically follows the conductive lines of an enlarged drawing to guide the tool in cutting highly accurate templates and cams—both internal and external.



In keeping with its embodiment of the latest engineering advances, this Pratt & Whitney machine uses Gilmer "Timing" ® Belts to drive the spindle at constant angular velocities, assuring the finest finishes and maximum tool life. Belts can be changed readily to any of three positions, in the manner of change gears, to provide various spindle speed ranges, permitting use of either High Speed Steel or carbide mills and small diameter grinding wheels.

The design engineer for Pratt & Whitney states, "From the very concept of this machine the Gilmer 'Timing' Belt principle was selected, and has proved to be a wise selection giving trouble-free power transfer throughout the exceptionally wide spindle speed range of 48 rpm to 11,500 rpm. The belts are used to insure positive drive with absolutely no slip and vibrationless operation of the spindle."

Are you planning one of the "machines of tomorrow"? Then follow the example of leading machine tool builders, both here and abroad, and design it around the Gilmer "Timing" Belt drive—the only type of drive that assures positive power transmission without need of lubrication! Your NYB&P Distributor can supply you with engineering data, as well as with Gilmer "Timing" Belts and pulleys.

NYB&P

NEW YORK BELTING & PACKING CO. 1 Market St., Passaic, N. J.

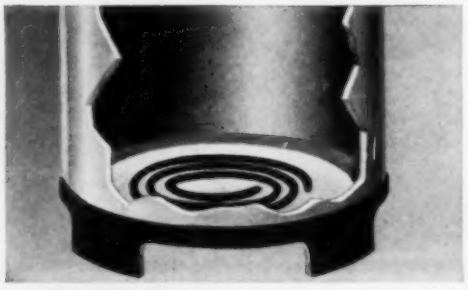
America's Oldest Manufacturer of Industrial Rubber Products

DESIGNING HEAT INTO YOUR PRODUCT?

G-E Heaters Can Be Formed to Your Exact Design; Big Selection Saves You Design and Production Time

HEATING LIQUIDS

1 **SIMPLIFIED DESIGN** and easy installation benefit maker of cement tester, who chose sturdy, flexible G-E tubular heaters.

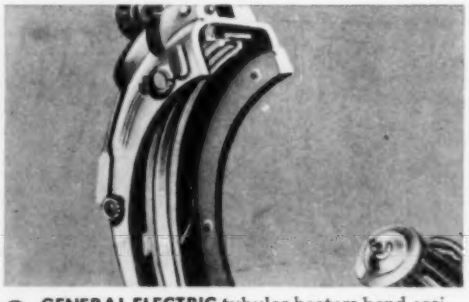


2 **SPACE LIMITATION** is easily overcome with General Electric tubular heaters, which can be formed readily to practically any shape . . . without danger of breaking.

3 **G-E TUBULAR HEATERS** simplify tester use. To begin test, operator need only plug in tester, load specimens, and turn on switch.

HEATING SURFACES

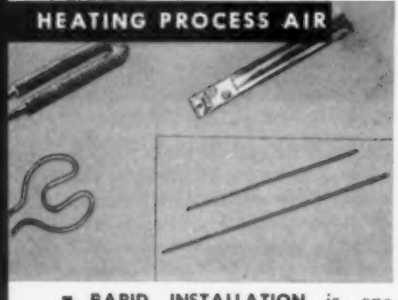
1 **FLEXIBLE BUT RUGGED** G-E tubular heaters are chosen by tire-retreader manufacturer after test. Other makes broke when formed.



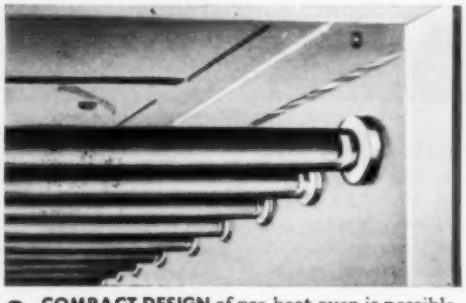
2 **GENERAL ELECTRIC** tubular heaters bend easily to the curved shape of tire retreader. Heaters are inserted into grooves in heating plate to gain maximum heat transfer.

3 **EXACT HEAT** required for top-quality retreading of huge truck tires is achieved with high-efficiency General Electric heaters.

HEATING PROCESS AIR



1 **RAPID INSTALLATION** is one benefit of uncomplicated design. Designer used straight-length tubular heaters in pre-heat oven.



2 **COMPACT DESIGN** of pre-heat oven is possible with inside-mounted General Electric tubular heaters, which replaced outside, top-mounted heaters formerly used.

3 **UNIFORM HEAT** throughout oven combines radiation and convection, since tubular heaters are mounted inside oven chamber itself.

Section G723-9, General Electric Company,
Schenectady 5, N. Y.

Name .....

Company .....

Street .....

City ..... State .....

FREE 1957 CATALOG

60-page Catalog of General Electric heaters and heating devices—describes full line. Also provides helpful application data. GEC-1005

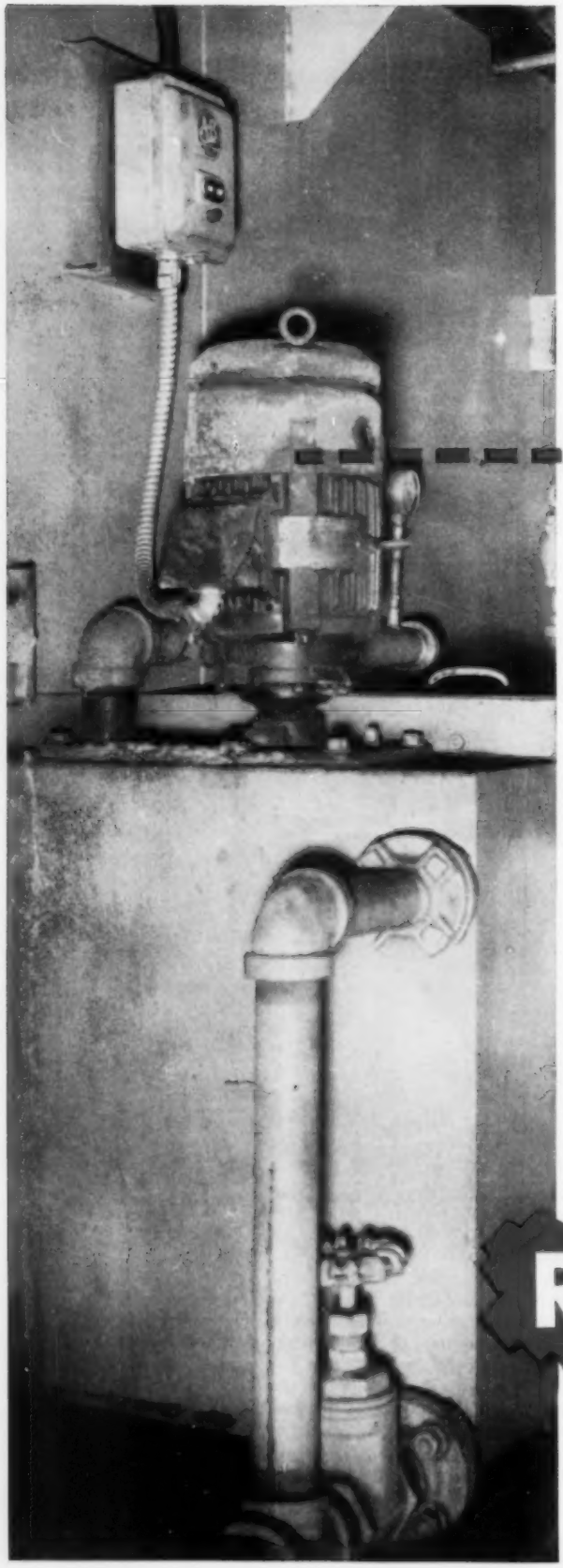
GENERAL ELECTRIC

Ready, Set, GROW... with

REVERE ALUMINUM TUBE

For aluminum tube that is right for its purpose and comes to you right on schedule, call the nearest Revere Sales Office. Revere is headquarters for tube . . . seamless drawn, welded, lockseam and other types, in an extensive range of sizes, alloys and tempers, both round and other than round. It will pay you to tie the growth of your business to the most dependable sources of supply. Revere Copper and Brass Incorporated. Founded by Paul Revere in 1801. Executive Offices: 230 Park Avenue, New York 17, N. Y.

Revere Aluminum Mill Products include coiled and flat sheet, both plain and embossed, circles and blanks, Tube-In-Strip,* extruded products, all types of tube, rolled shapes, electrical conductors, forgings, foil, and frozen food containers. *Revere's trademark for sheet metal containing inflatable channels.



RELIANCE solves motor corrosion problem

This Reliance Corrosion-Proof Motor is operating a pump which circulates cleaning solution through a tank containing metal parts. The motor is subjected to corrosive vapors and liquids each time a basket of parts is removed. BUT THIS MOTOR WILL NOT CORRODE.

The solid cast-iron housing, including the fan cover, will withstand corrosive service indefinitely. Wiring identification is preserved on a stainless steel name plate. A threaded outlet is provided on the water tight conduit box, and motor leads are molded into a neoprene gasket that completely seals off the windings from the conduit box. A neoprene or non-ferrous shaft slinger seals the only other frame opening.

These and many other features give you a motor with a built-in corrosion protection. Why not install this superior design now and save many replacement dollars in the years ahead.

Write for bulletin B-2406 for complete design details.

B-1534

RELIANCE ELECTRIC AND ENGINEERING CO.

DEPT. 307A, CLEVELAND 17, OHIO

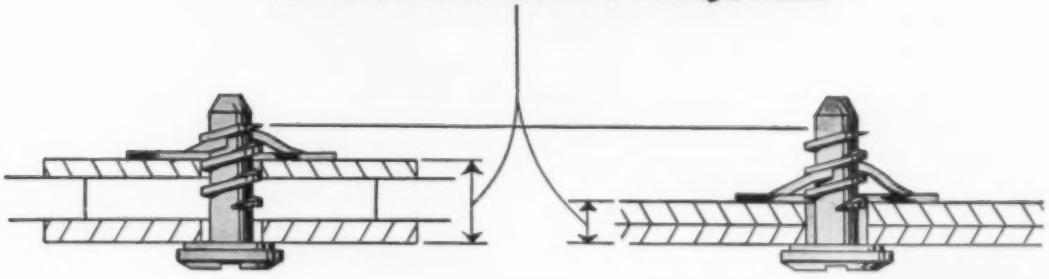
CANADIAN DIVISION: WELLAND, ONTARIO

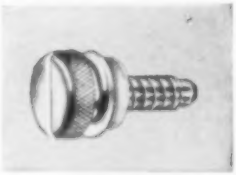
Sales Offices and Distributors in Principal Cities

Why change cowl fastener size every time tolerances vary .010" ?

SOUTHCO **quick release fasteners provide:**

±TOLERANCES AS REQUIRED





Industrial tolerances, provided only by Southco Quick-Release Fasteners, are designed to accommodate variations in thickness normally encountered in metal working. No longer is it necessary to call out a different size precision type fastener because of a few thousandths variation. You eliminate a serious stock problem and reduce assembly time when you specify SOUTHCO.

You can easily choose the right Southco Quick-Release Fastener from a wide variety of stock sizes which include two diameters and three head styles.

The Southco Handbook makes it easy to pick the proper fastener. Write for your copy today. Southco Division, South Chester Corporation, 236 Industrial Highway, Lester, Pa.

© 1954

SOUTHCO DIVISION
SOUTH CHESTER CORPORATION
236 Industrial Highway, Lester, Pa.

Please send me, without cost, the 24 page SOUTHCO FASTENER HANDBOOK ☐

Please have representative call ☐

NAME _____

POSITION _____

COMPANY _____

ADDRESS _____

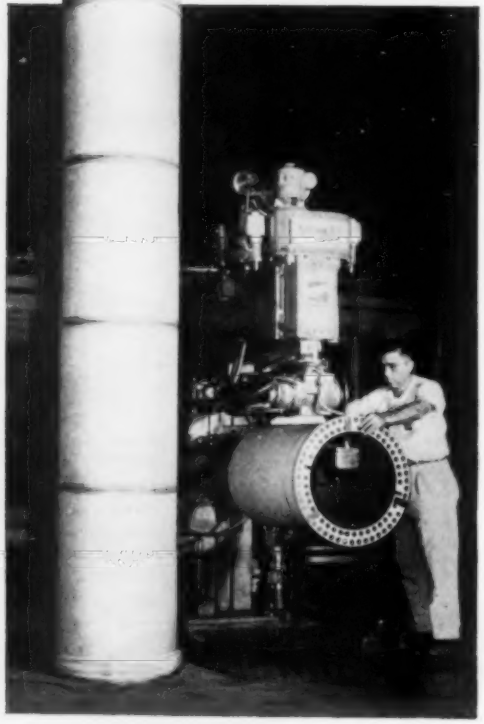
CITY _____ ZONE _____ STATE _____

SOUTHCO® **FASTENERS**

LION

HEAT • WEAR • CORROSION

HAYNES Alloys solve the

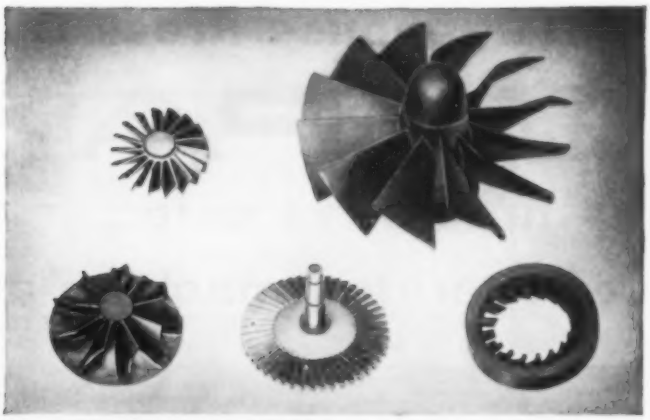


HEAT

2,000 degree jet blast!

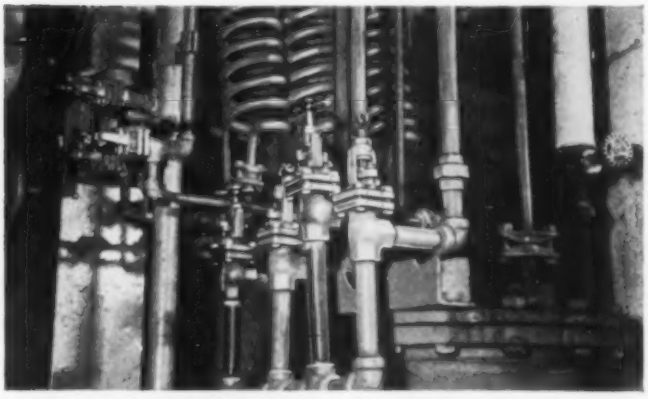
The jet engine tailpipe of the Navy's A4D "Skyhawk" operates at extremely high temperatures. That is just one of the many reasons why this part is made of MULTIMET alloy. This is one of 6 HAYNES wrought alloys that have unusual resistance to high temperatures and oxidation. Because of their exceptional properties, HAYNES alloys are being used extensively in such parts as after-burner components, jet engine tailpipes, turbine blades, and nozzle vanes.

tough problems



PRODUCTION Intricate turbine wheels mass-produced.

HAYNES' investment-casting method offers a selection of alloys developed for economical operation over a wide temperature range. Blades and wheels are produced as one integral part to as-cast tolerances that permit operation with unusually fine clearances at high speeds.



CORROSION Withstands corrosive chlorine 10 years!

Handling highly corrosive liquid chlorine was an expensive maintenance problem – until valves made of HASTELLOY alloy C were installed. This is just one of the many corrosive difficulties met by HAYNES Alloys. They also have excellent resistance to hot mineral acids, strongly oxidizing salts, and powerful gaseous oxidants over a wide range of temperatures and concentrations.

If you have an application that is creating a tough heat, wear, or corrosion-resistance problem, you will find it profitable to check with HAYNES Stellite Company. In practically every industry, you will find HAYNES Alloys doing a better job, lasting longer, reducing maintenance and proving most economical.

Tell us your problem and we will send you descriptive literature on the HAYNES Alloy best suited to solve it. Write HAYNES STELLITE COMPANY, Division of Union Carbide Corporation, General Offices and Works, Kokomo, Indiana.

HAYNES
ALLOYS
HAYNES STELLITE COMPANY
Division of Union Carbide Corporation

UNION CARBIDE

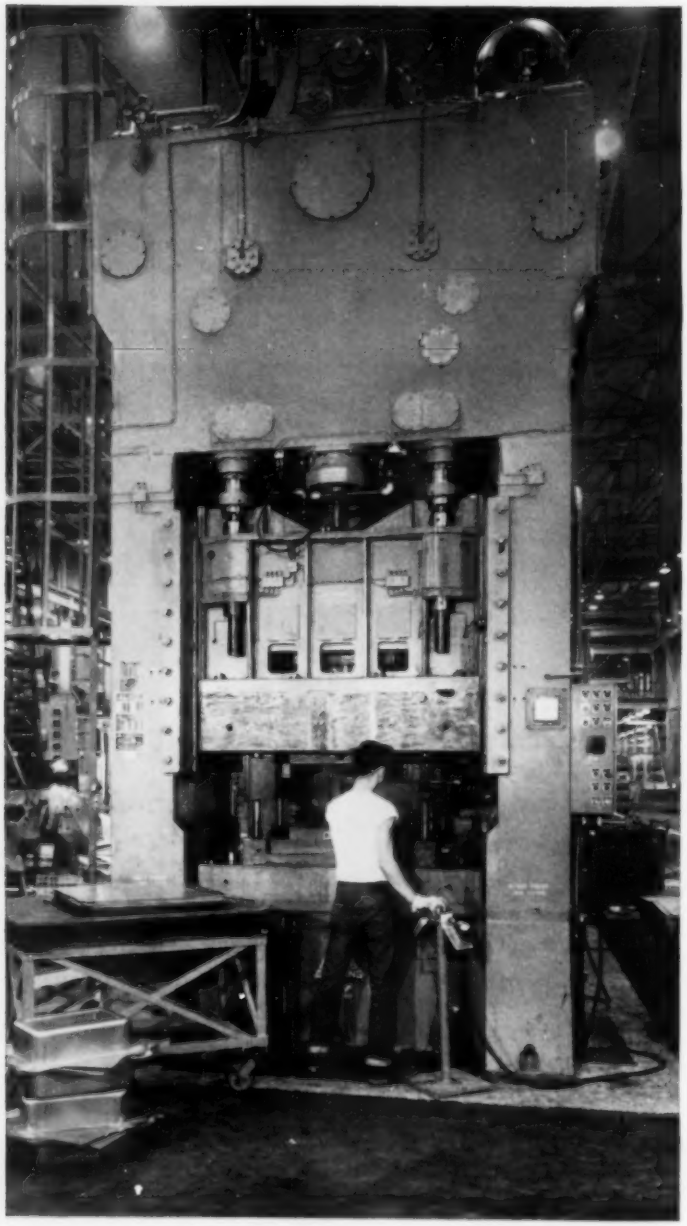
"Haynes," "Multimet," "Hastelloy" and "Union Carbide" are registered trade-marks of Union Carbide Corporation.

Westinghouse Press Control with

CYPAK

is three-ways safe...

for operator, machine and work.



Westinghouse Press Control with CYPAK* offers a new high in industrial safety for machine operator, the machine dies and blanks, and work material.

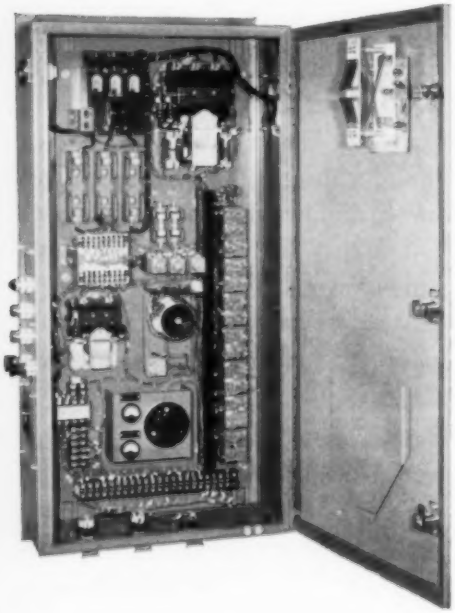
Because CYPAK eliminates the use of relays, there are no mechanical parts to stick or jam in the control and cause a repeat of the press. Patented anti-repeat clutch control circuit is self-checking, calling for two impulses to initiate a stroke.

Standard control has a four-position selector switch and run-pushbutton that are key-locked. An externally operated circuit breaker is another safety feature.

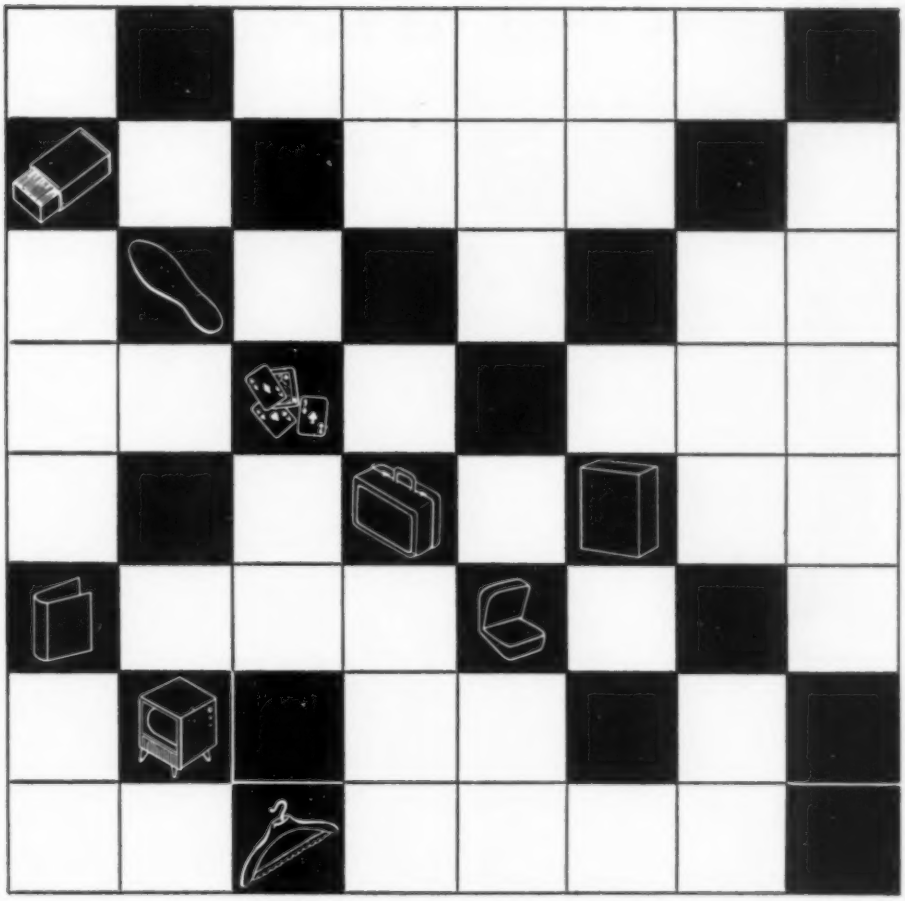
For complete information on reliably safe Westinghouse Press Control with CYPAK, call your Westinghouse Sales Engineer. Or, write Westinghouse Electric Corporation, 3 Gateway Center, P. O. Box 868, Pittsburgh 30, Pa.

*Trade-Mark

J-22050



YOU CAN BE SURE...IF IT'S Westinghouse



help solve the puzzle of product design . . .

WITH BOXBOARD BY GAIR!

This versatile material fabricates into almost any shape and lends itself to many new uses. In addition to making superior folding cartons and set-up boxes, Gair Boxboard excels as book covers, game boards, shoe innersoles, shelving, coat hangers, templates, chair seats, luggage boards, partitions, furniture and TV backs, and in dozens of other industrial and re-sale fabrications.

If you are designing a new product or improving an old one, Gair Technical Service will show you why it pays to create products and components with boxboard by Gair. Consistent high-quality in a great variety of grades, colors, coatings, laminations and treatments . . . fast delivery when and where you need it. Call your Gair representative or write Gair, today.

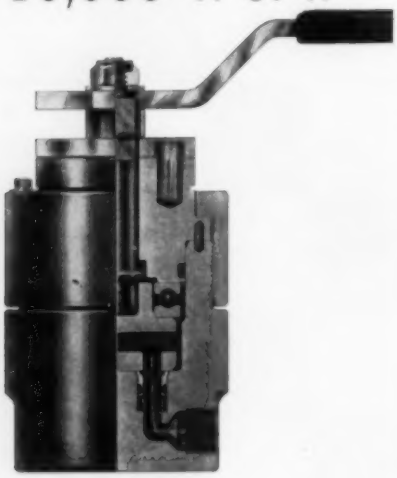
GAIR *boxboard*

SPRINGBOARD TO MORE SALES

BOXBOARD AND FOLDING CARTON DIVISION OF CONTINENTAL CAN COMPANY

155 EAST 44th STREET, NEW YORK 17, N.Y.

NEW 'SHEAR-SEAL' VALVE FOR 10,000 P. S. I.



This new "Shear-Seal" shut-off valve rated for liquids or gases to 10,000 P.S.I. will withstand surges of up to 15,000 P.S.I. without damage to the valve or its leakproof operation. It is designed for a burst pressure of 40,000 P.S.I.

The "Shear-Seal" principle is an exclusive Barksdale development for the control of extreme pressures and has a long history of successful industrial application. Lapped optically flat sealing surfaces of the sealing rings and the mating rotor face are protected by keeping in constant intimate contact; flow is always through the center of the "Shear-Seal" never across sealing surfaces, as in conventional valve design. Sealing qualities actually improve as the self-aligning "Shear-Seals" lap themselves to a more perfect fit with each valve operation. The infinitesimal amount of wear is taken up by a back-up spring.

Valves will be furnished for pipe, tube, AND 150 or any preferred special high pressure connection. For complete information on the "Shear-Seal" design and its application in your particular high pressure valve problem write for "Shear-Seal" bulletin.

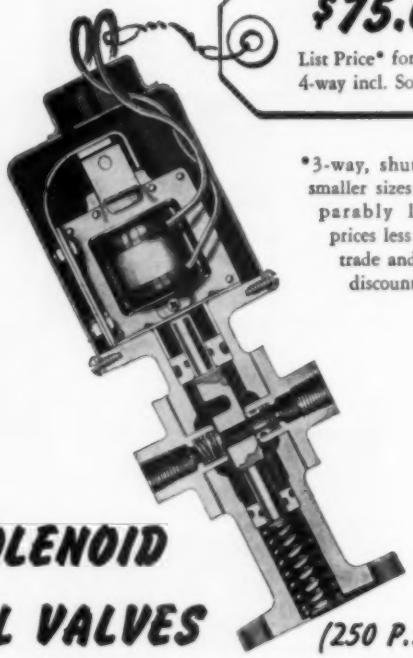
BARKSDALE VALVES

5125 Alcoa Avenue, Los Angeles 58, California

LEAKPROOF (SHEAR-SEAL)

$75.00
List Price* for a ½" 4-way incl. Solenoid

*3-way, shut-off and smaller sizes are comparably less. All prices less the usual trade and quantity discounts.



SOLENOID OIL VALVES (250 P.S.I.)

WHERE	WHY	HOW
Thread rolling machines	Holding position (leakproof)	Lapped sealing surfaces seal tight indefinitely as a result of wear compensation
Pressure testing in automotive production	Oil gets contaminated by scale in castings (not critical to dirt) reduced maintenance	Sealing surfaces in constant, intimate contact, dirt can't lock valving members – saves coil burn-out
Hydraulic work feed apparatus	(Leakproof) . . . as versus spool valves which cause over-demand on hydraulic system	Positive shut off of internal port to port leakage and of course, no external leakage
Machine tool chucking & clamping	Maintaining safe holding pressure (leakproof)	Saving auxiliary equipment such as pilot operated check valves
Automatic door openers	Quick action (high flow capacity)	No spools or poppets obstructing full, round flow passages
Solenoid controlled hydraulic system on machine you build	Better performance	Shear-Seal valves have full flow, are leakproof, not sensitive to dirt
	Lower manufacturing costs	Low priced, less auxiliary equipment and labor cost.
	Reduce service problems	Valves don't stick, saving coil burn-out; stay leakproof indefinitely, seals are wear compensating

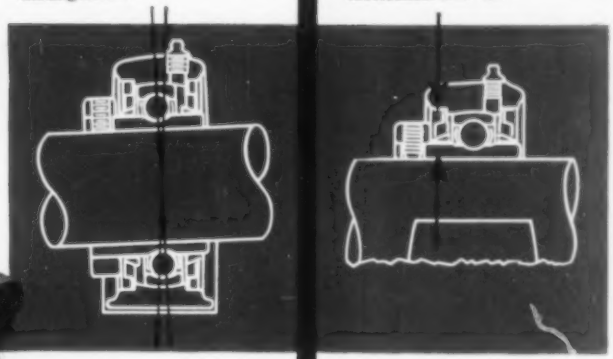
BARKSDALE VALVES

5125 Alcoa Avenue, Los Angeles 58, California
Ask for bulletin 5S-H

Self-aligning SEAL AND ALL

SELF-ALIGNMENT is assured because the lubricated, spherical outer ring is free to align in any direction. Full load capacity is always maintained regardless of shaft deflection or misalignment.

POSITIVE PROTECTION of the rolling elements from moisture, dust and dirt is provided by self-aligning seals extending from housing to inner ring. Large grease reservoir prolongs lubrication intervals.



Series 200 and 300 ball bearings

That's why grease stays in, dirt out of these LINK-BELT ball bearings

To compensate for supports and shafts that misalign in service . . . for unavoidable inaccuracies in mounting—Link-Belt offers self-alignment in ball bearings. And to protect that vital feature against dust and dirt, Link-Belt provides effective seals that *align along with rolling elements.*

Self-alignment is standard throughout industry's most complete line of ball and roller bearings—pillow blocks and flange, flange cartridge, cartridge and take-up units. Ask any one of 40 Link-Belt offices for Book 2550.

14.330-A

LINK-BELT

THE SYMBOL OF QUALITY — LB — LINK-BELT

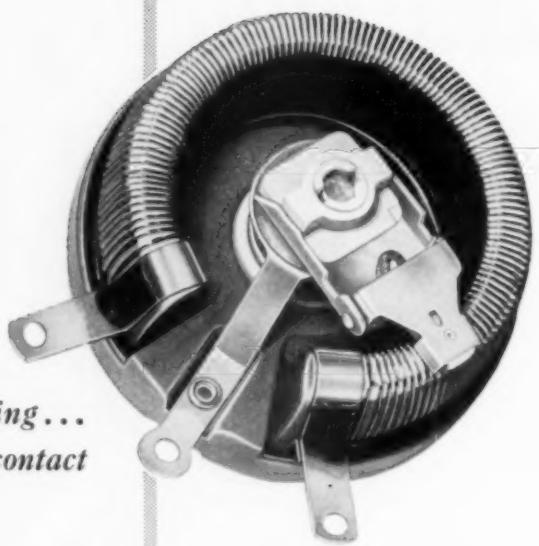
self-aligning ball and roller bearings

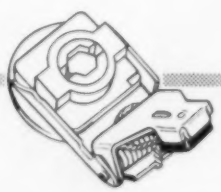
LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office: New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville (Sydney), N.S.W.; South Africa, Springs. Representatives Throughout the World.

Mallory

the only power rheostat of its kind!

unique hinged contact arm permits easy inspection and cleaning... provides constant pressure for good contact





No hot contacts... constant, correct spring pressure! The Mallory design always maintains correct spring pressure because it is coil-spring loaded. Heavy-duty pigtails by-pass the current around the spring —heavy loads never destroy tension by overheating the spring material. A variety of springs is available, providing a choice of contact pressures—resulting in low contact resistance yet maintaining long rotational life characteristics.

Conservatively rated, Mallory rheostats run *cool*. A high grade porcelain base and a tough porcelain-enameled core are fused together under high temperatures to provide a unit that is resistant to shock and vibration.

The core is smoothly wound with resistance wire drawn to rigid Mallory specifications. Special tapers can be provided to individual customer specifications. These tapers incorporate a new, exclusive Mallory-developed process that eliminates unsightly wire splices.

Mallory rheostats are available in 8 sizes: 25-watt, 50-watt, 75-watt, 100-watt, 150-watt, 225-watt, 300-watt, and 500-watt. For special requirements, Mallory engineers will design units to meet your particular specifications.

Complete catalog information and technical data on Mallory Power Rheostats may be had on request. Ask for Mallory design and application assistance to fill your exact requirements.

Expect more... Get more from

P. R. MALLORY & CO. Inc.

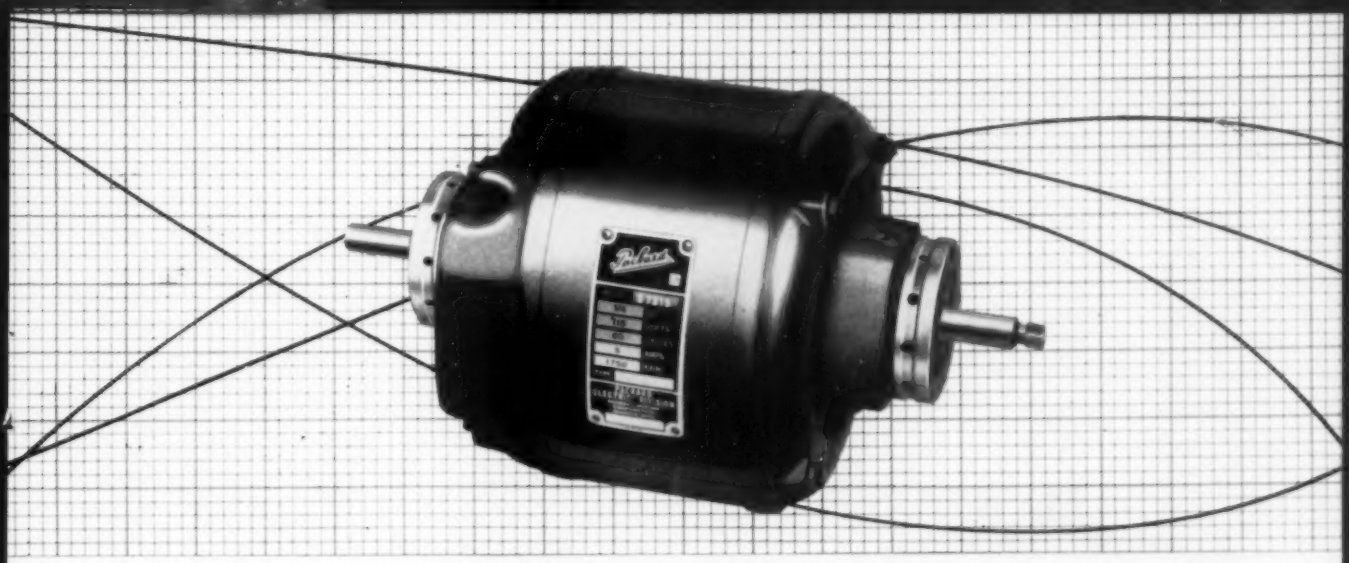
MALLORY

P. R. MALLORY & CO. Inc., INDIANAPOLIS 6, INDIANA

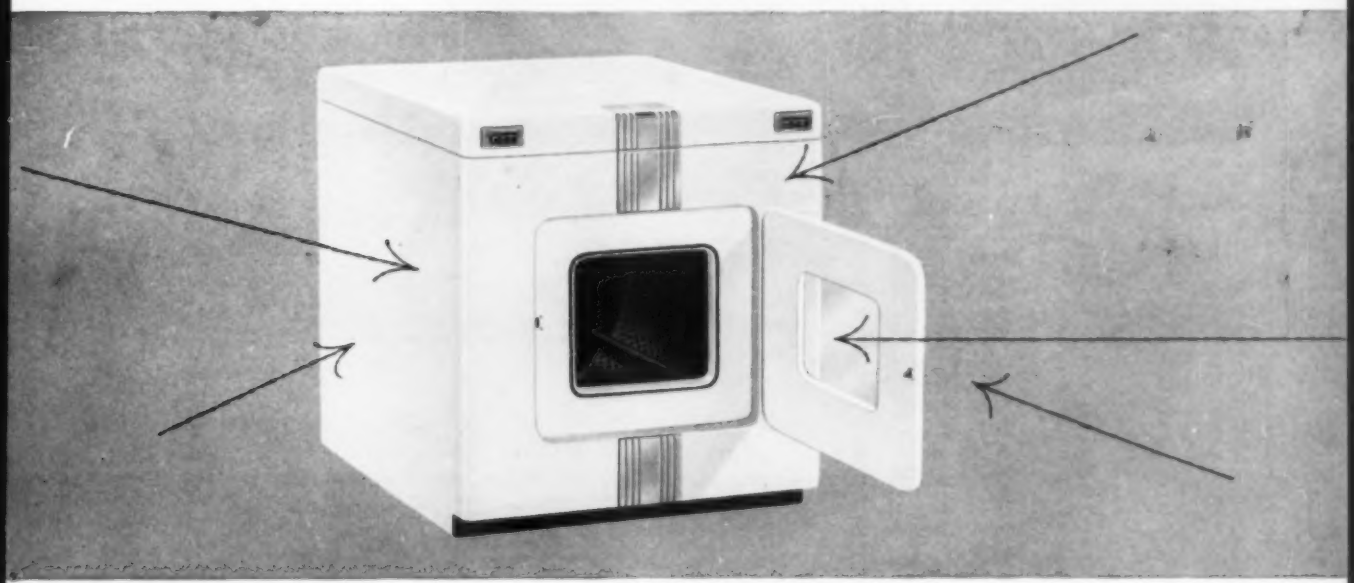
Serving Industry with These Products:

Electromechanical — Resistors • Switches • Tuning Devices • Vibrators
Electrochemical — Capacitors • Mercury and Zinc-Carbon Batteries
Metallurgical — Contacts • Special Metals • Welding Materials

Parts distributors in all major cities stock Mallory standard components for your convenience.



PACKARD ELECTRIC / *Because this motor was custom-tailored*



FHP MOTORS / *this dryer is built better at lower cost!*

Packard Electric direct factory sales and engineering contact consistently pays off. In this case it did for a dryer manufacturer.

The payoff came in a motor custom-tailored to dryer requirements . . . not merely a conveniently adapted motor. This means that the motor has the exact characteristics—speed, power and torque—for its job. Because of that, it could be advantageously priced.

What's more, it can be supplied with power supply cord already attached—complete and ready for installation. This results in still more savings.

Packard Electric research and engineering teams are busy today developing new motors. And as always, our objective is to enable customers to produce better, lower priced products in the future.

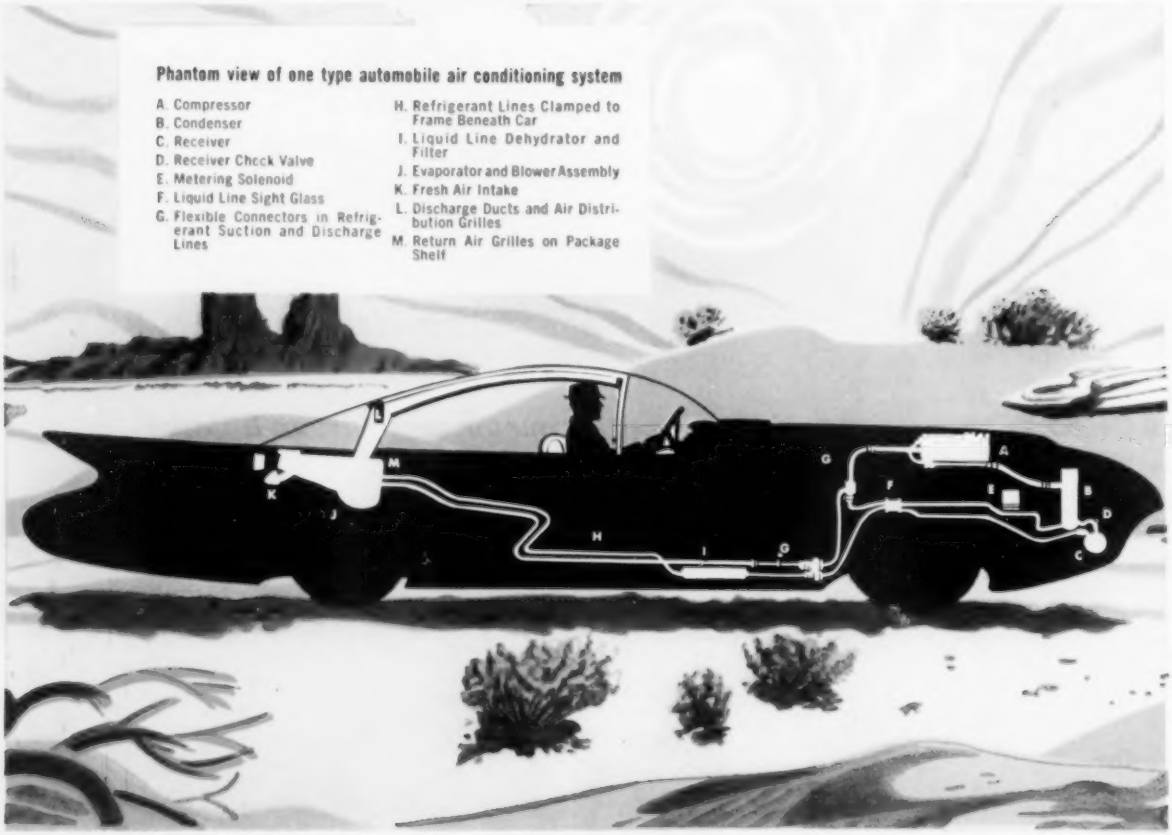
Packard Electric

Warren, Ohio

GM GENERAL MOTORS

Division of General Motors

Naugatuck PARACRILS


Phantom view of one type automobile air conditioning system
A. Compressor
B. Condenser
C. Receiver
D. Receiver Check Valve
E. Metering Solenoid
F. Liquid Line Sight Glass
G. Flexible Connectors in Refrigerant Suction and Discharge Lines
H. Refrigerant Lines Clamped to Frame Beneath Car
I. Liquid Line Dehydrator and Filter
J. Evaporator and Blower Assembly
K. Fresh Air Intake
L. Discharge Ducts and Air Distribution Grilles
M. Return Air Grilles on Package Shelf

cool!

Air conditioning an automobile is not a new idea... just one that presented a variety of material specification problems. One of the most important of these problems was the need for a rubber with low enough permeability to be used as a vehicle for commercial refrigerants. This was solved with a Paracril® rubber.

Paracrils are Naugatuck's butadiene acrylonitrile rubbers. Rubbers capable of carrying refrigerants while possessing outstanding resistance to oils, fuels, aromatic hydrocarbons and many hydraulic fluids. In addition Paracrils provide:

- **superior aging resistance, even at elevated temperatures,**
- **high and low temperature flexibility,**
- **outstanding abrasion resistance,**
- **unusual tensile properties,**
- **the best resistance to air and gas permeability.**

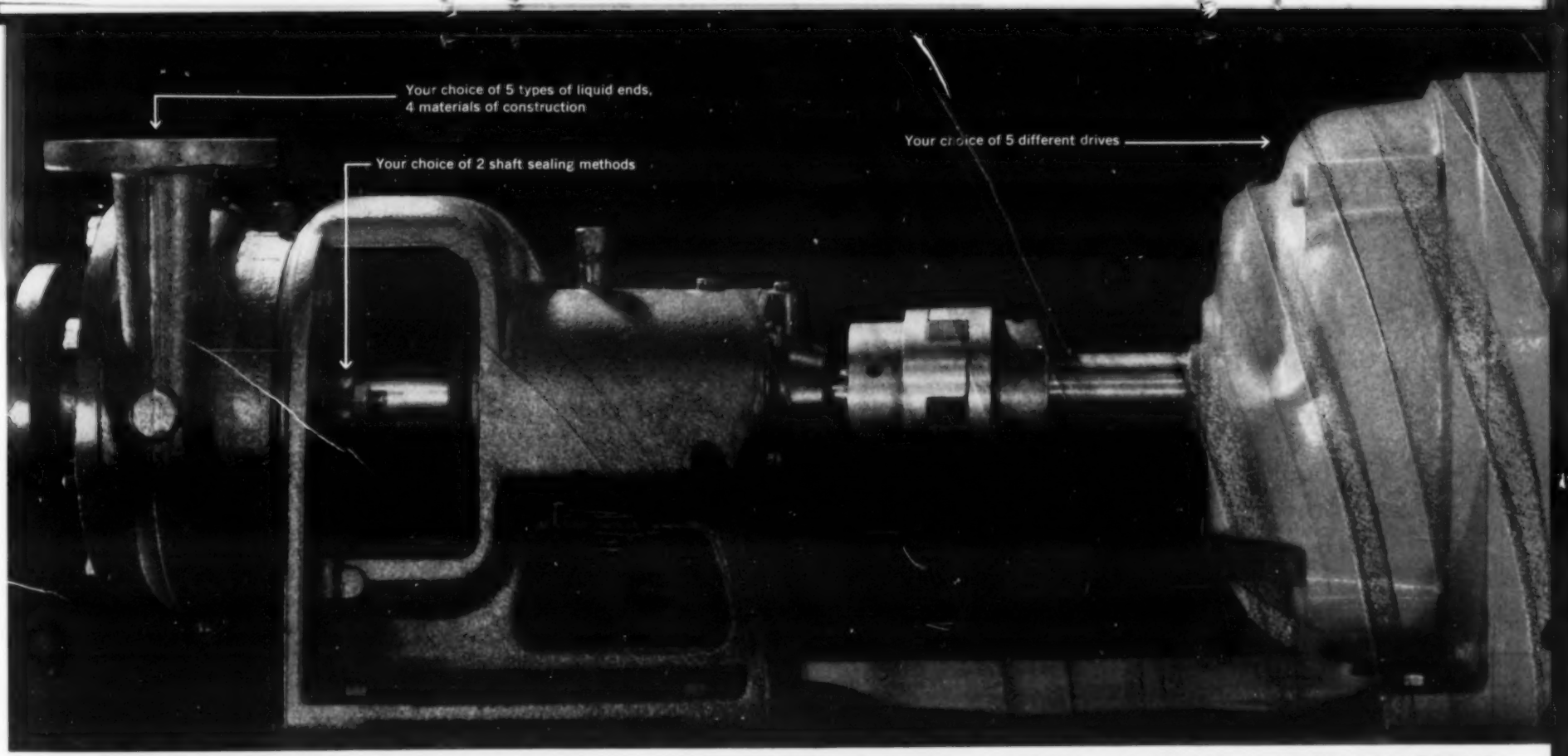
For complete information on how the *oil-resistant Paracril* family can help you improve or develop a product, write to us, *today*.

Naugatuck Chemical

Division of United States Rubber Company
Naugatuck, Connecticut

US RUBBER

IN CANADA: NAUGATUCK CHEMICALS, Elmira, Ontario • Cable Address: Rubexport, N.Y.
Rubber Chemicals • Synthetic Rubber • Plastics • Agricultural Chemicals • Reclaimed Rubber • Latices


Your choice of 5 types of liquid ends, 4 materials of construction
Your choice of 2 shaft sealing methods
Your choice of 5 different drives

COMPLETELY STANDARD–YET BUILT TO YOUR SPECIFICATIONS

Here's the development that gives you standard pumps tailored to your own individual specifications.

Instead of paying "special" prices for a specially designed unit, you can literally "custom build" your pump from the 70,480 combinations in Worthington's SESC–Standard End Suction Centrifugal–pump line.

Based on standardization of "parts" not "pumps" the SESC pump line gives you great flexibility in meeting special requirements in hydraulic coverage, corrosion problems and sealing methods *without* extensive design changes and modification expense.

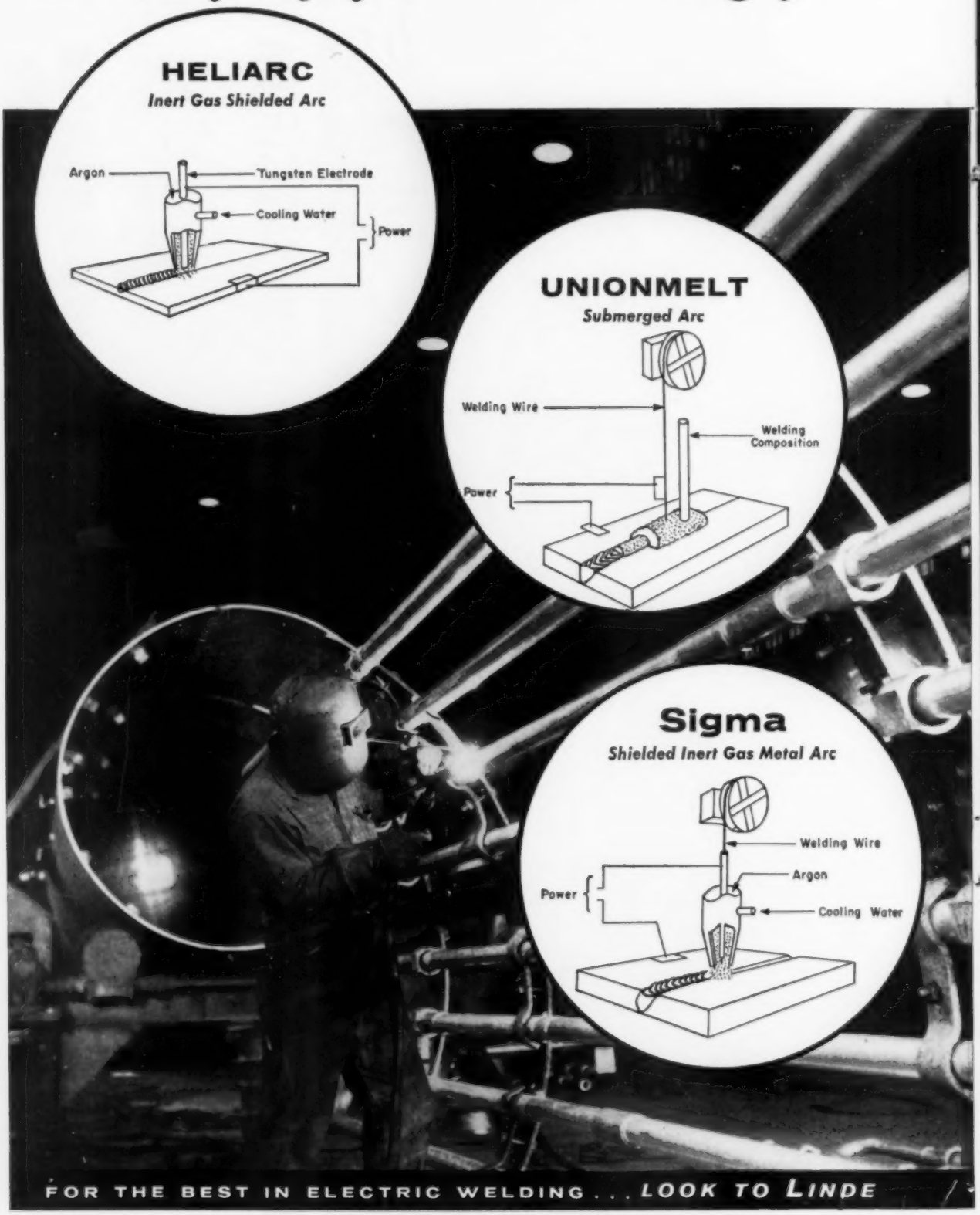
For example, you have a choice of materials of construction–iron, steel, bronze, Worthite* and combinations of these–to meet all types of corrosive conditions. Hydraulic coverage can't be matched. There are 120 different sizes with ratings up to 2,700 GPM and 550 ft. head. You have a choice of stuffing box or mechanical seal operation. Both open and enclosed impellers are available.

Your Worthington representative will be happy to discuss the SESC pump program with you to see how it can improve your product's performance or reduce engineering and design expense. Or write for a copy of Bulletin W-300-B4B. Address Section SP-77, Worthington Corporation, Harrison, N. J. In Canada: Worthington (Canada) 1955 Ltd., Brantford, Ont.

*A high nickel, high-chromium, low-carbon alloy steel. Trademark Reg. U. S. Pat. Off.

WORTHINGTON

For any of your welding jobs



. . . LINDE can supply the *right method!*

Inert gas shielded arc welding—

HELIARC Apparatus for inert gas shielded arc welding, using a tungsten electrode and a shield of LINDE argon, is tops for joining hard-to-weld commercial metals. On stainless steel and aluminum, HELIARC Welding is fast and clean, producing high-quality welds that resist corrosion. HELIARC Welding eliminates costly grinding and finishing, making it a valuable method for quantity production of hard-to-weld metals.

Submerged arc welding—

Shapes made of materials ranging from light gage to heavy plate, adaptable to mechanization, can be most economically joined by UNIONMELT Welding. It is used on low and medium carbon steels and alloy steels, including those containing chrome and/or nickel. UNIONMELT Welding is also used extensively for resurfacing metal, providing extra wear and corrosion resistance. UNIONMELT Welding is fast and inexpensive on production jobs.

Shielded inert gas metal arc welding—

One of the most versatile welding methods is Sigma Welding. LINDE's Sigma apparatus, using a shield of LINDE argon, is ideal for manual welding of commercial metals ⅛ in. or more thick, and for automatic operation on lighter gage metals to .050 in. Highest quality welds can be made on aluminum thicker than ⅛ in. at speeds up to 16 inches per minute. Build-up and surfacing jobs are also improved by using LINDE's Sigma welding method.

New! *Magnetic flux gas shielded arc welding—*

UNIONARC Welding, LINDE's most recent development in electric welding, is an extremely fast method for welding mild steel. This method employs a continuously-fed, bare steel wire electrode, magnetically coated with flux conveyed in a stream of carbon dioxide shielding gas. Manual welds can be made easily in any position—vertical, overhead, downhand—with no stops to change electrodes. The speed, versatility, and ease of operation of of UNIONARC Welding brings costs down 25% to 65% below those of manual covered electrode welding. Clean, smooth, high-quality welds are provided, even in the presence of moderate amounts of rust, scale, and moisture.

Engineers at LINDE have been designing, developing, and testing electric welding methods and apparatus for many years. Help on any welding method is yours for the asking. You can improve your work and cut production problems by taking advantage of LINDE's experience. For data on UNIONARC Welding or any other electric welding method, call the LINDE office nearest you.

LINDE COMPANY, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, N. Y. Offices in other principal cities. *In Canada:* Linde Company, Division of Union Carbide Canada Limited.

Linde
TRADE-MARK

UNION CARBIDE

The terms "LINDE," "HELIARC," "UNIONMELT," "UNIONARC," and "UNION CARBIDE" are trade marks of Union Carbide Corporation.

FORD BUILDS FOR THE FUTURE WITH

CYPAK

... controlling form grinder sequencing in automatic transmission production

CYPAK* static controls have already outlasted conventional relays previously used at the Ford plant in Livonia, Michigan. No down time for control maintenance has been necessary with this highly repetitive operation in over 17 months!

Logic and sequencing control of two Springfield Machine Tool Co. form grinders is performed by CYPAK static control apparatus. CYPAK activates the solenoids of hydraulic valves controlling the grinder's feed cycle.

In machining the impeller housing of automatic transmissions, the operator places the workpiece in the chuck, presses the cycle button ... and CYPAK does the rest ... automatically.

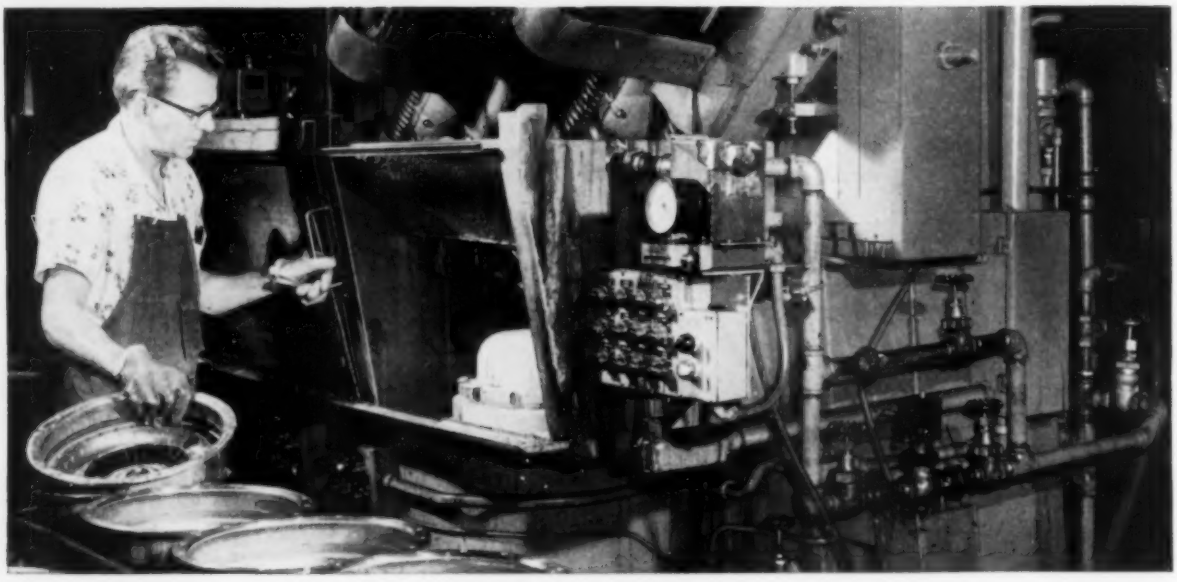
For complete information about CYPAK call your Westinghouse representative, or write Westinghouse Electric Corp., Dept. B, P.O. Box 868, Pittsburgh 30, Pa.

*Trade-Mark

J-22019

YOU CAN BE SURE... IF IT'S

Westinghouse



ANNOUNCING...

the Beryllium Copper ROLLPIN®

Strong . . . highly resistant to corrosion . . . nonmagnetic . . . extremely conductive

Now you can use Rollpin to cut assembly and maintenance costs in a whole new group of applications. A new line made of beryllium copper, one of the strongest of the copper base alloys, opens the door to a wide variety of uses where resistance to corrosive attack, good electrical properties and other unusual characteristics are required. These slotted tubular copper spring-pins can be used in assemblies that range from plumbing fixtures to electrical instruments, particularly in conjunction with other copper base alloy components.

Rollpin has already established its ability to replace taper pins, straight pins and set screws; to serve as a rivet, dowel, hinge pin, cotter pin or stop pin . . . eliminating special machining, tapping and the need for hole reaming or precision tolerances. Driven into a hole drilled to normal production standards, it locks securely in place, yet can be readily drifted out and reused whenever necessary.

Rollpin is available in beryllium copper from .062″-diameter to .250″-diameter, and in steel and stainless steel up to .500″-diameter.

ELASTIC STOP NUT (ESNA) **CORPORATION OF AMERICA**

Dept. R35-72, Elastic Stop Nut Corporation of America
2330 Vauxhall Road, Union, New Jersey

Please send me the following free fastening information:

☐ Data on beryllium copper Rollpin

☐ Here is a drawing of our product. What self-locking fastener would you suggest?

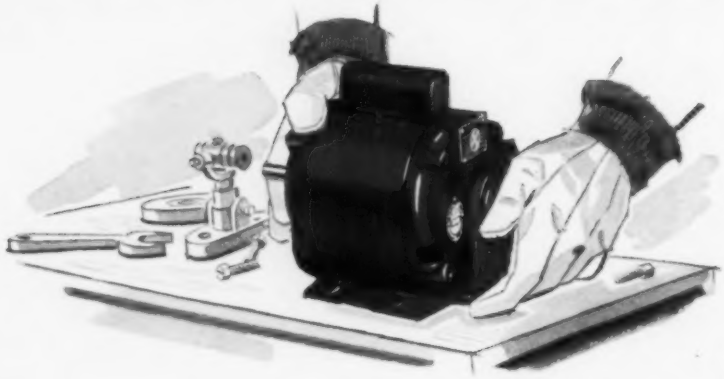
Name_____ Title_____

Firm_____

Street_____

City_____ Zone_____ State_____

some want 'em small



some want 'em

big

some want 'em in between

Whatever your motor requirements — you'll find the right answer at .....

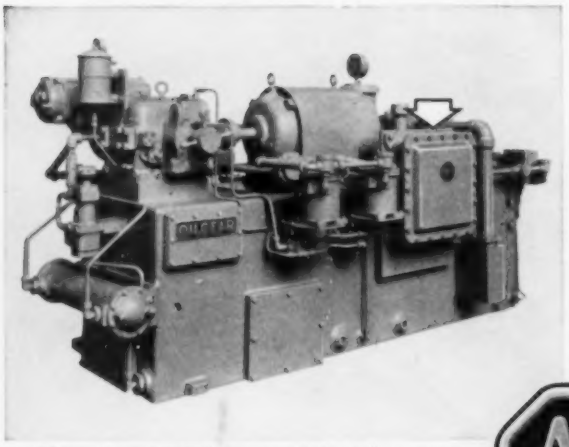
Through research A.O. Smith *... a better way*

A.O.Smith

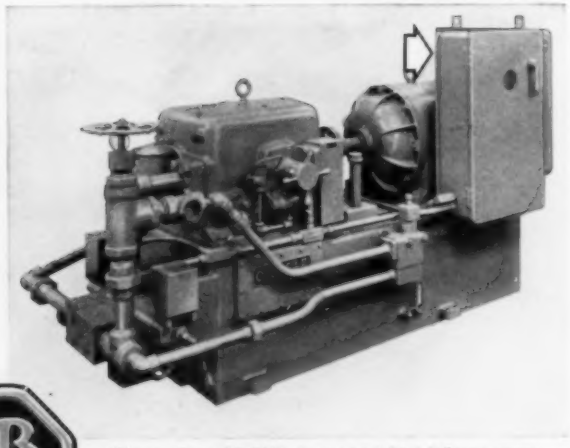
CORPORATION

ELECTRIC MOTOR DIVISION
Tipp City, Ohio
INTERNATIONAL DIVISION: Milwaukee 1, Wisconsin

GET ALL THE FACTS TODAY about A. O. Smith's full range of application-engineered motors, including hermetic, vertical hollow-shaft and gear motors — ¼ thru 150 hp. Write for Bulletin No. EM 157-B, or refer to your Sweet's Product Design File.

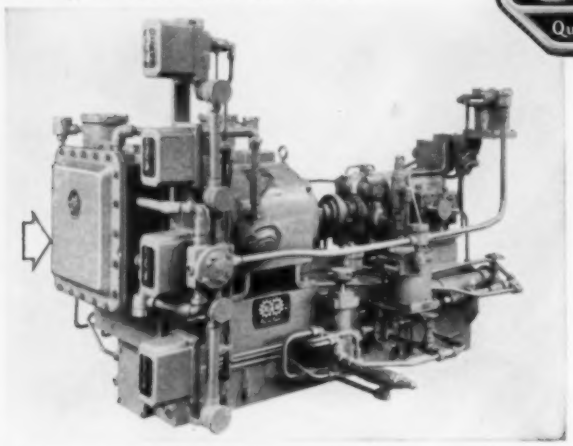


Oilgear Type DXE-825 2-way variable delivery pump for large Cordite press. Allen-Bradley motor controls in Type 7 explosion-proof bolted enclosure.

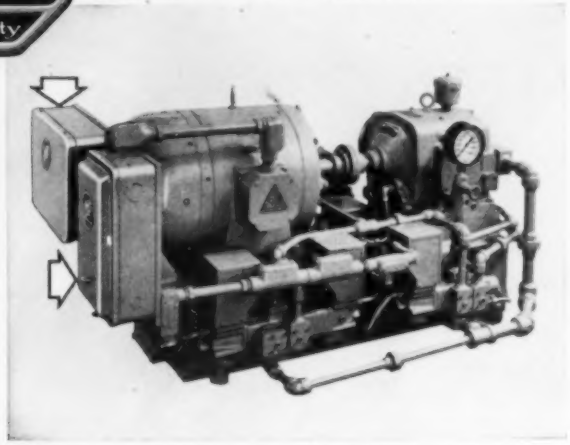


Oilgear Type DR-3511 1-way variable delivery pump for fluid power to gun gymnasticater. Allen-Bradley motor controls in Type 1 general-purpose enclosure.

A-B Quality



Oilgear Type DXG-425 duplex pump for fluid power to large Cordite extrusion press. Allen-Bradley motor controls in Type 7 explosion-proof bolted enclosure.



Oilgear Type DS-825 1-way variable delivery pump for fluid power to machine tool. Allen-Bradley motor controls mounted in Type 1 general-purpose enclosure.

OILGEAR FLUID POWER PUMPS ...use Allen-Bradley Motor Controls

The four powerful oil pumps shown above, and built by The Oilgear Company for delivering fluid power to large extrusion presses and other hydraulic machinery, are factory-equipped with Allen-Bradley solenoid motor starters. The enclosures used are determined by the conditions existing where the pumps are installed.

Why is Allen-Bradley control so popular with machinery builders? The answer is found in the solenoid design. Its one moving part is a virtual guarantee of millions of trouble free operations.

In addition, the double break, silver alloy contacts—used throughout the Allen-Bradley line—eliminate all need of maintaining contacts—they are always in perfect operating condition. Where bolted enclosures are used, maintaining contacts becomes a costly, time-robbing job.

Another outstanding advantage is the protection afforded by the accurate and reliable overload relays. Being solder pot relays, they do not deteriorate with age—they remain accurate and reliable.

Send for a copy of the Allen-Bradley Handy Catalog . . . a good reference manual on motor controls . . . manual and automatic. Write for your copy, today.

Bulletin 700 relay for machine tools.

Bulletin 709 solenoid starter removed from enclosure to show arc hood and two overload relays. Available up to 300 hp, 220 v; 600 hp, 440-550 v.

Allen-Bradley Co.
1329 S. First St.
Milwaukee 4, Wis.

ALLEN-BRADLEY
SOLENOID MOTOR CONTROL
QUALITY

In Canada—
Allen Bradley Canada Ltd.
Galt, Ont.

VICTOR TORCH with cutting tip of Anaconda Tellurium Copper, which has the resistance to heat and wear required to maintain uniform flame characteristics through a long life of service.

Tellurium Copper makes better cutting and welding tips

Two typical Victor torch tips of Anaconda Tellurium Copper-127 shown full size.

THE PROBLEM: Victor Equipment Company of San Francisco first used regular leaded copper rod in making tips for its line of cutting and welding torches. In some applications, however, the leaded copper did not stand up under high heat conditions.

THE SOLUTION: Victor tried Anaconda Tellurium Copper-127 Rod and found the answer. The Tellurium Copper had a much higher heat resistance. This meant long, trouble-free service for its precision-made cutting and welding torches in all types of applications. At the same time, the Tellurium Copper provided uniform machinability, especially important in drilling the deep holes prior to completion by swaging on mandrels.

FREE TECHNICAL SERVICE: No matter what your special problem may be, The American Brass Company can very likely furnish free-cutting copper and copper-alloy rod to meet the requirements of the product or the operation.

It is the function of the Technical Department of The American Brass Company to assist metal users in the selection of Anaconda Rod. This service is at your disposal without charge or obligation. Comprehensive data on composition and machinability of standard Anaconda Rod Alloys, together with specification references, weights and dimensions, are available in Publication B-3. For this booklet – or technical assistance – write: The American Brass Company, Waterbury 20, Conn. 3765

ANACONDA® COPPER and COPPER ALLOYS

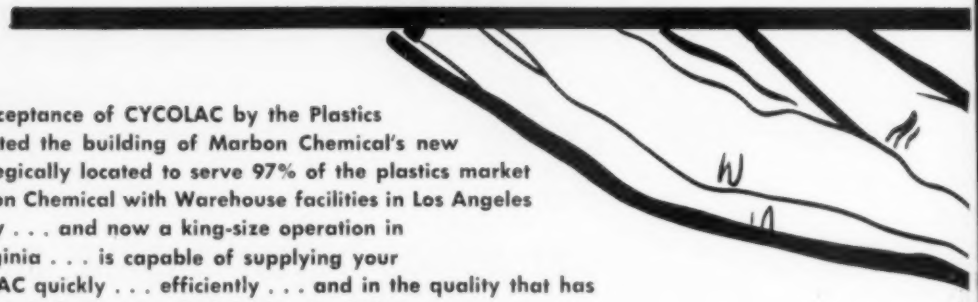
MADE BY THE AMERICAN BRASS COMPANY

Marbon Chemical's new Woodmar Plant

READY TO SERVE THE

CYC

New



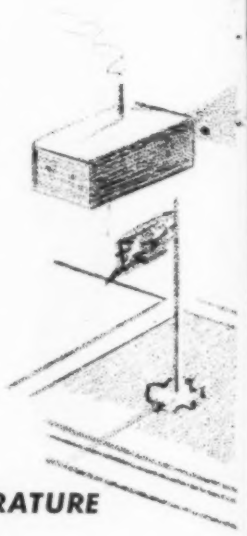
The enthusiastic acceptance of CYCOLAC by the Plastics Industry accelerated the building of Marbon Chemical's new Woodmar Plant. Strategically located to serve 97% of the plastics market within 48 hours, Marbon Chemical with Warehouse facilities in Los Angeles . . . two plants in Gary . . . and now a king-size operation in Washington, West Virginia . . . is capable of supplying your every need for CYCOLAC quickly . . . efficiently . . . and in the quality that has in two short years made it the buy-word of the Plastics Industry.

FACTS about Cycolac

- Single uniform resin, permanently thermoplastic permitting fast molding, calendering and extruding.
- High in impact-resistance and heat distortion temperatures; low in brittle point.
- Economical to form from press-polished sheets by vacuum, air-pressure, or mechanical methods over inexpensive molds of wood, plaster, aluminum, etc.
- Very light — Sp. Gr. 1.01. Dimensionally stable, readily injection-molded.
- Capable of being solvent or heat-welded; can be machined.
- Free from nerve or shrinkage, permitting accurate calendering and extruding.

FACTS about the plant

- Total area of 337 acres with a fenced area of 65 acres completely serviced by Truck - Rail - and River facilities.
- All buildings constructed of incombustible material, sprinklered, and properly dispersed for maximum safety.
- 150′ x 300′ Warehouse equivalent to size of football field.
- Five wells producing one million eight hundred gallons of water per day.
- Area under roof totals 138,000 sq. ft.
- 57 miles of electrical cable fed by 5,000 KVA source.



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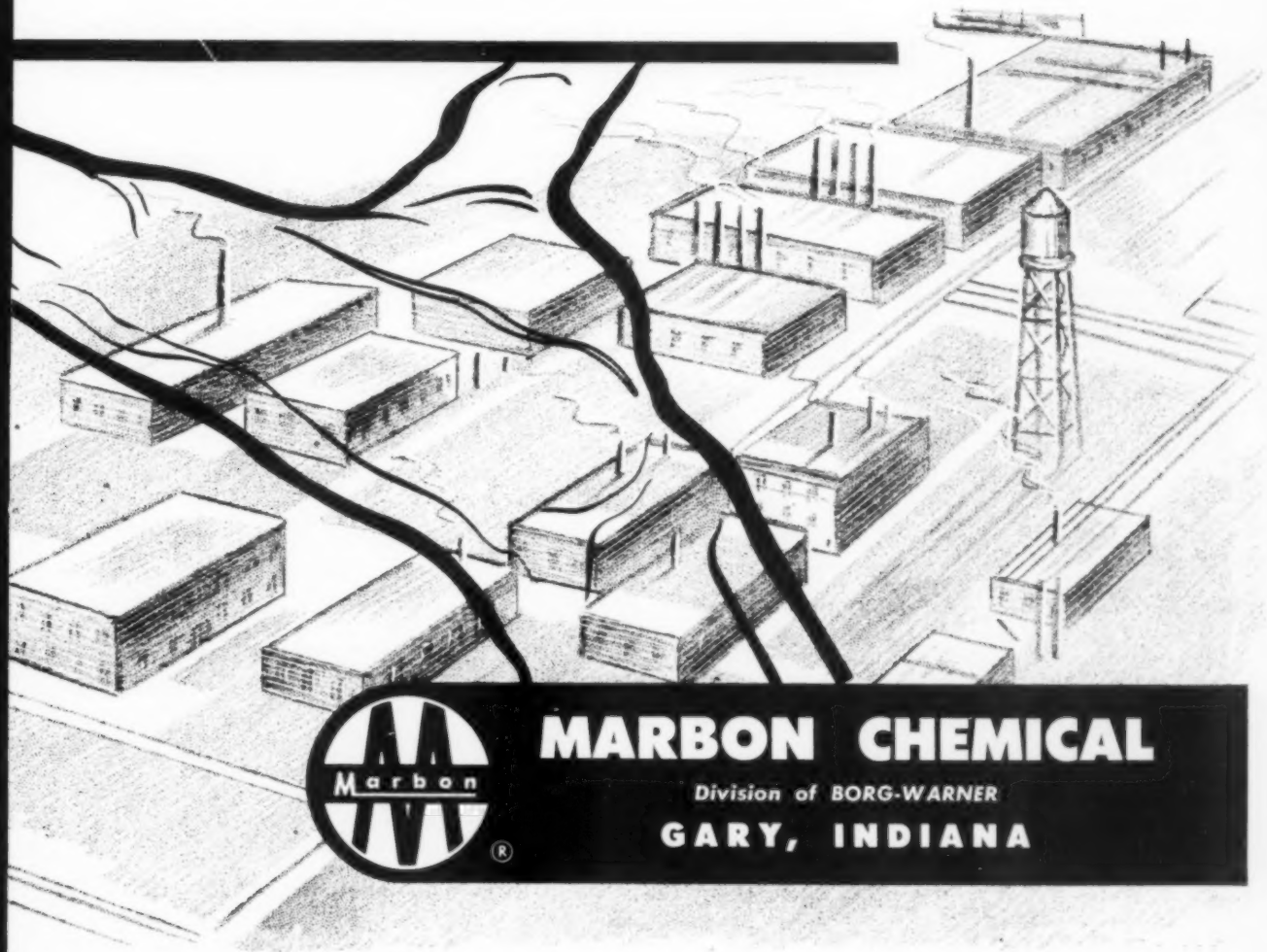
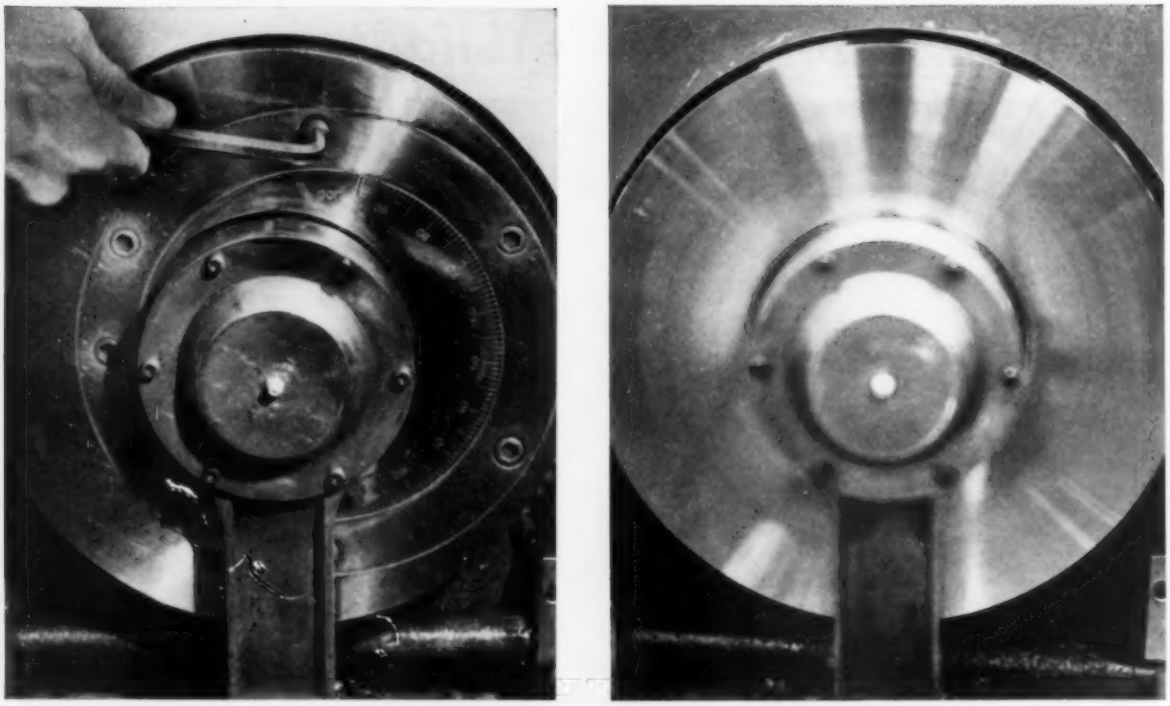


MARBON CHEMICAL

Division of BORG-WARNER

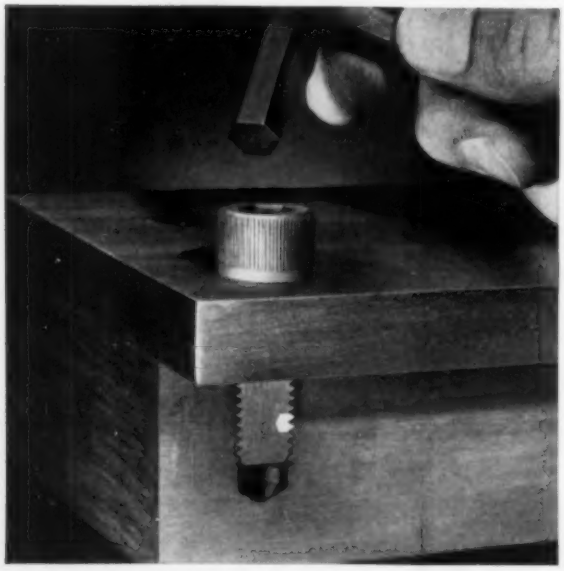
GARY, INDIANA



Self-locking UNBRAKO socket screws keep critical adjustments secure in the eccentric drive mechanism of this fatigue testing machine. Drive system delivers varying loads up to 15,000 pounds force to equipment under test at 1050 cycles per minute.

Vibration won't loosen Self-locking UNBRAKO socket cap screws

Screws with Nylok* device permit adjustments, keep precise settings during long test runs



HOW IT LOCKS. The tough, resilient Nylok locking pellet keys itself into the mating threads. It forces threads together, and locks the screw securely—whether or not the screw is seated.

UNBRAKO socket screws with the Nylok self-locking device stay tight under constant vibration.

Take the eccentric drive system in the fatigue testing machine illustrated above, for example. This machine must frequently run for periods up to 2 weeks or longer, day and night, to complete a single test. Loosening of the screws which are used to adjust the tension-setting mechanism could not only cause damage to the machine, but also make the test data worthless. Self-locking UNBRAKO socket head cap screws eliminate such problems.

An UNBRAKO socket screw with the Nylok self-locking device is a single unit. Just screw it into any tapped hole. Seated or not, it locks positively wherever wrenching stops. Constant vibration or pounding, or endless running of a machine, won't affect these self-locking UNBRAKOs. The screws will not work loose!

Write today for your copy of Form 2193, which gives complete catalog and technical data on the entire line of UNBRAKO socket screws with the Nylok self-locking device. Or see your authorized industrial distributor. Unbrako Socket Screw Division, STANDARD PRESSED STEEL CO., Jenkintown 28, Pa.

UNBRAKO® SOCKET SCREW DIVISION

STANDARD PRESSED STEEL CO.

SPS

JENKINTOWN ■ PENNSYLVANIA

*T.M. Reg. U.S. Pat. Off. The Nylok Corporation

INTRODUCING GRAPH-AIR...

a tougher, more versatile graphitic tool steel that air-hardens at temperatures 200° to 300° lower with less distortion!

NO facilities for oil-quenching—or other relatively costly heat treating processes? Need a finer air-hardening tool steel? Then specify *Graph-Air,* newest steel resulting from the Timken Company's pioneering in fine alloy steels. Latest addition to our line of quality graphitic tool steels!

Graph-Air tool steel air-hardens at temperatures of 1450°F to 1550°F—200° to 300° lower than most other air-hardening tool steels. And because Graph-Air *is* air-hardened, there's less distortion, easier heat treating control, less decarburizing. As a result, Graph-Air can be made into *more intricate sections.* Graph-Air is a tough air-hardening steel, too—made to order for such demanding applications as blanking dies, or any tool steel part which must take hard abuse.

Besides all the advantages of air-hardening—economy, less drastic reactions to quenching, less tendency to scale—Graph-Air offers greater wear, machinability and stability. Like Graph-Mo, Graph-Air will outwear other tool steels, because of the uniform diamond-hard carbides in its structure. Graph-Air stays *accurate longer,* is fully as stable as other Timken Company graphitic tool steels, which are the most stable tool steels made!

Growing out of the Timken Company metallurgists' long experience with fine steel making, Graph-Air—the *new* graphitic tool steel that can be air-hardened at *low* temperatures—will be available in both solid and hollow bar sizes. For more information, write: The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable address: "TIMROSCO".

TIMKEN *Fine Alloy* **STEEL**

TRADE-MARK REG. U.S. PAT. OFF.

SPECIALISTS IN FINE ALLOY STEELS, GRAPHITIC TOOL STEELS AND SEAMLESS STEEL TUBING

NEW

THESE 4 FEATURES MAKE NEW R & M ARMATURES OUTSTANDING

■

All coils are wound simultaneously. Coils are exactly identical, assuring identical electrical and physical characteristics. Conventional methods produce windings with individual coils having varying amounts of wire and consequent non-symmetry.

■

Armature coils are uniformly positioned and anchored securely. Interlocked winding pattern resists conductor and coil end movement. This unique construction minimizes abrasion of wire insulation, a common cause of high speed armature failure.

■

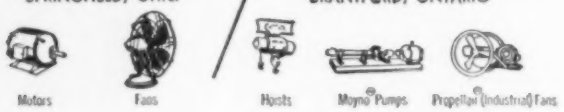
Maximum coil end exposure resulting from distinctive winding pattern permits maximum heat dissipation. Lower temperatures prolong armature life.

■

More uniform electrical characteristics reduce arcing at brushes, improving commutation and prolonging brush life.

ROBBINS & MYERS, INC.

SPRINGFIELD, OHIO | BRANTFORD, ONTARIO

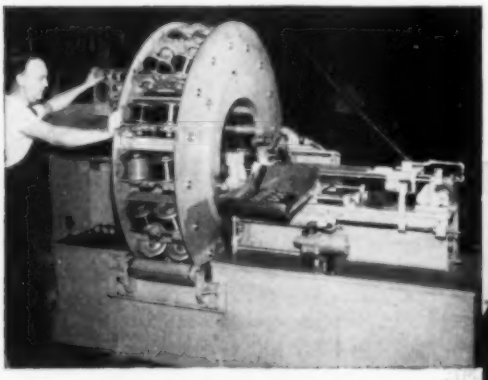


R & M PRECISION MACHINE-WOUND ARMATURES

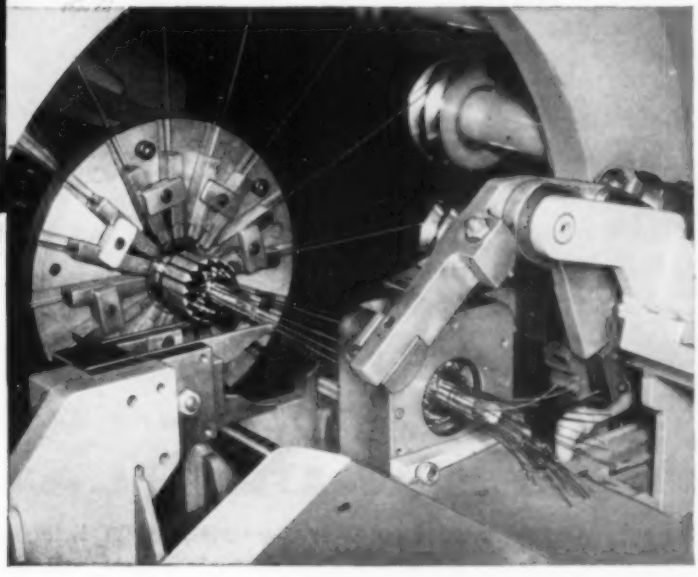
can improve your product's performance!

A new basic development in armature winding technique, perfected by Robbins & Myers, now produces armatures for Universal or Series Motors which are superior to those heretofore available for original equipment manufacturing. The new R & M armature winding machine winds all coils simultaneously . . . uniformly positions them . . . and the coils are physically and electrically identical! Weaknesses inherent in armatures wound by conventional methods are eliminated. The new R & M machine produces armatures of finer, more uniform construction which will give longer, more dependable service!

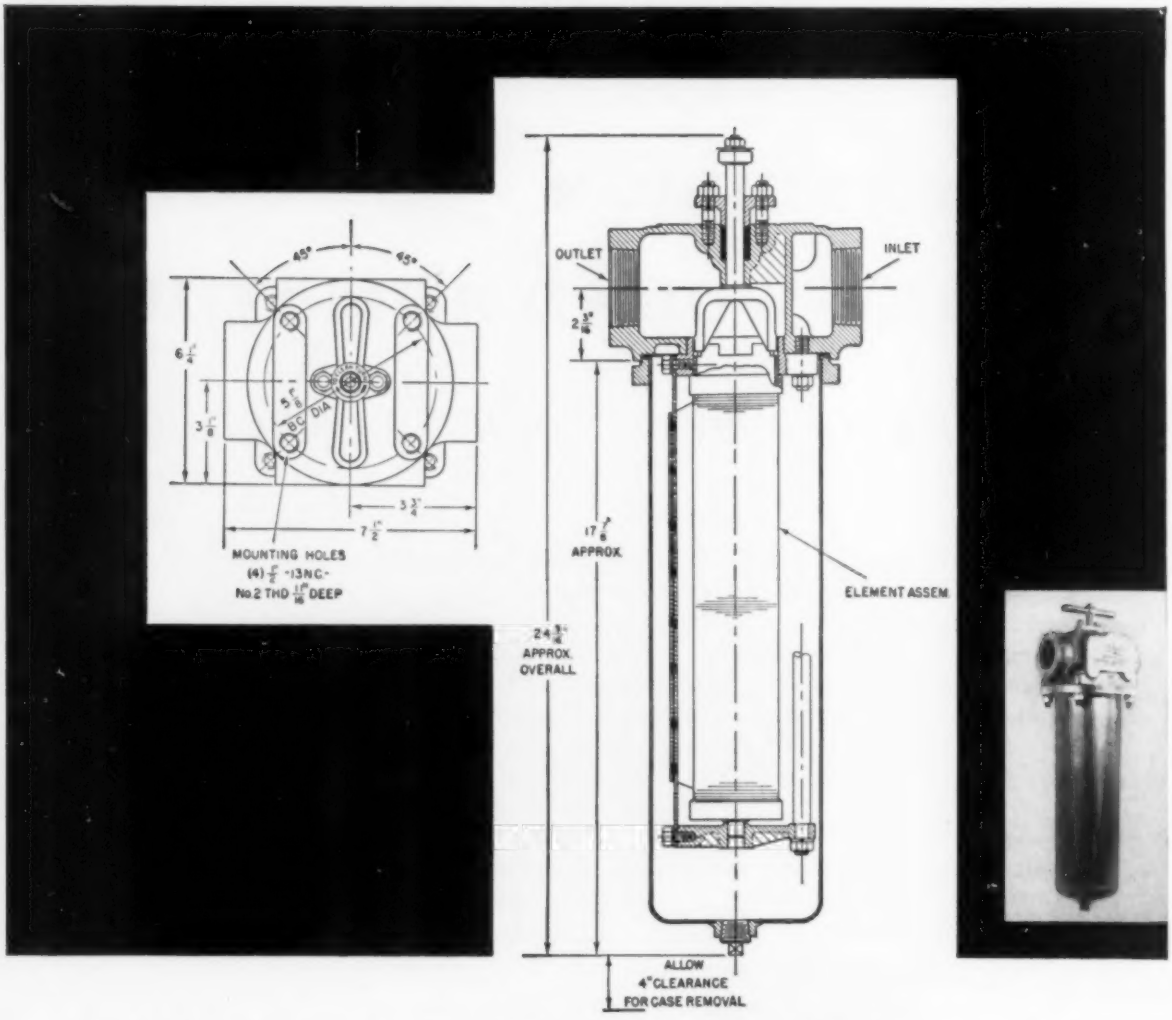
Contact a Robbins & Myers representative for additional details on R & M universal motors and series motor parts or write for Bulletins 444-PE and 455-PE.



AUTOMATION AT R & M SPEEDS ARMATURE WINDING AND IMPROVES ELECTRICAL AND PHYSICAL QUALITIES OF PRODUCT.



R&M



Your "special" filtration problems can be solved by standard Purolator filters

FOR EXAMPLE... This one standard Purolator filter is exactly right for all these "special" filtration problems:

inks, paints,
varnishes, machine tool coolants,
greases, vitamin solutions,
as well as fuel and lube oils.

This filter's specifications may recommend it for a problem of yours. If not, you're almost certain to find a standard Purolator filter that does meet your needs—exactly.

SPECIFICATIONS... This is Purolator filter model G-141J with simplex full flow metal element oil strainers. It is designed for primary or first stage filtration and can be installed on pressure or suction side of pump. Recommended for maximum capacities of 40 to 80 GPM, dependent on spacing which varies from .003 to .010. Relief valves set from 10-12 to 50 PSI are incorporated in several models. Motor driven knife blade to clean element can be furnished whenever conditions make manual rotation impractical. Head is made of high tensile cast iron, body of drawn steel. Inlet and outlet connections are 2", drain plugs are provided. Maximum pressure: 125 PSI; weight: 37 lbs.

Remember, if these specifications don't match your needs, there's probably a filter that does at Purolator. Find out. Send in your problem.

Filtration For Every Known Fluid

PUROLATOR

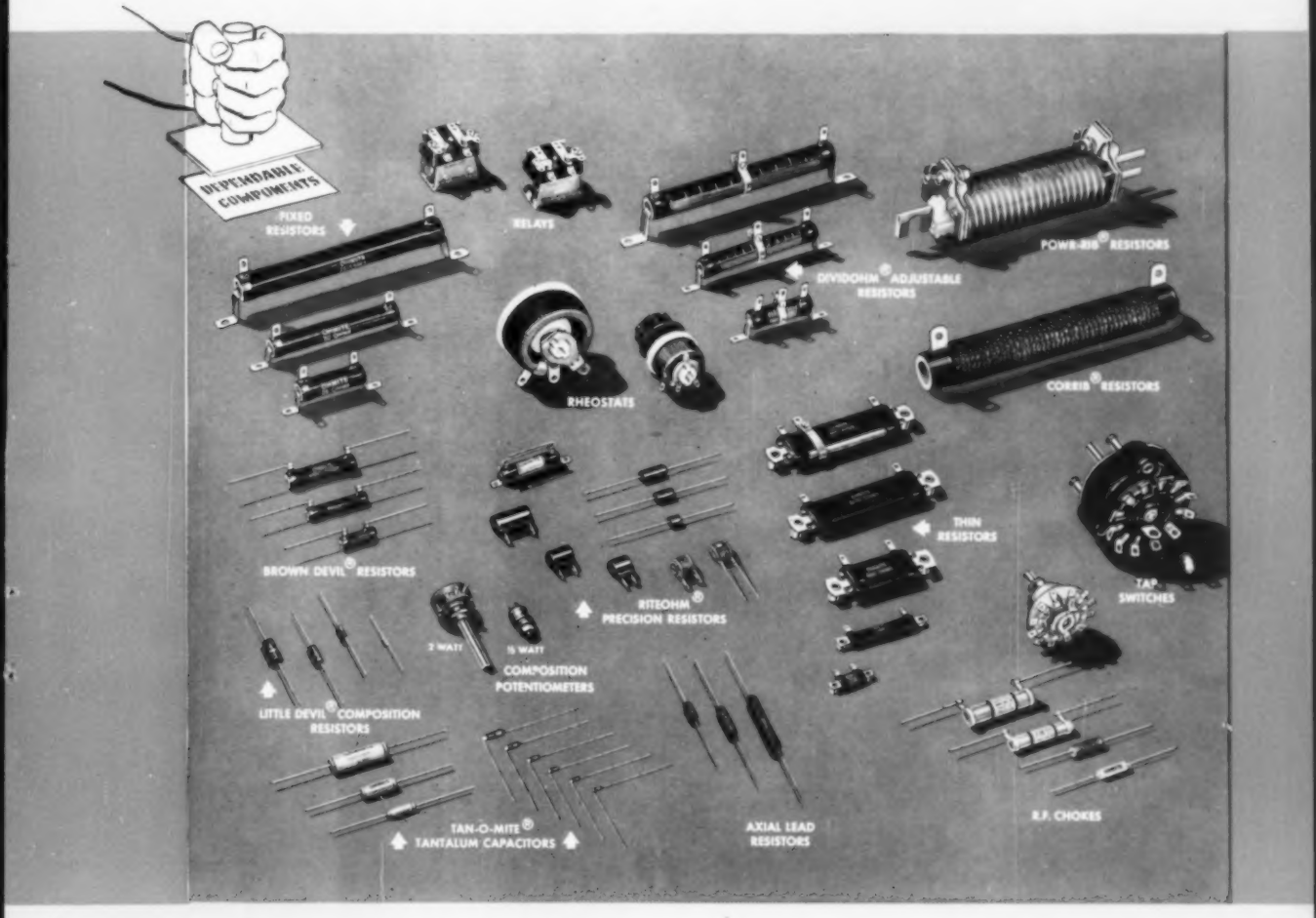
PRODUCTS, INC.

Rahway, New Jersey and Toronto, Ontario, Canada

OHMITE®

the complete line of industry-preferred COMPONENTS

Long life and dependability are synonymous with the name Ohmite. When you specify Ohmite components . . . you build reliability into your product. This reliability is backed by Ohmite's continuing research programs which explore new product ideas, improve present products, and develop more efficient manufacturing processes. All this plus the fact that Ohmite is the world's leading specialist in the manufacture of power-type resistance components —high quality rheostats and wire-wound resistors in the most complete range of sizes and types available to industry. Reliability is also characteristic of Ohmite tap switches, precision wire-wound resistors, molded composition resistors and potentiometers, general-purpose relays, subminiature tantalum capacitors, and R. F. chokes. Write on company letterhead for the complete Ohmite Catalog and Engineering Manual.



OHMITE®

BE RIGHT WITH

RHEOSTATS • RESISTORS • RELAYS • TAP SWITCHES • TANTALUM CAPACITORS

OHMITE MANUFACTURING COMPANY • 3611 Howard Street, Skokie, Illinois

solve many difficult control problems...use

OHMITE®

RHEOSTATS

with special features

Ohmite offers not only a line of *standard* rheostats but also rheostats with a wide variety of *special features*. Illustrated are only a few. All have the distinctive Ohmite design features: smoothly gliding metal-graphite brush; all-ceramic construction; insulated shaft and mounting; windings permanently locked in place by vitreous enamel. You will find the special rheostat feature you need in the dependable Ohmite line.

BUSHINGS FOR SPECIAL THICKNESS

Extra-long bushings and shafts for panels up to 2" in thickness. Seven bushing lengths.

SCREW DRIVER SLOT SHAFT

Shaft ends slotted for operation with a screw driver where few adjustments are needed.

VENTILATED CAGES

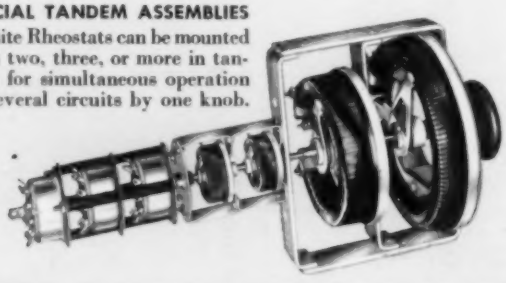
Prevents mechanical injury to rheostat or human contact with electrically "live" parts.

SENSITIVE SWITCH

Opens or closes circuit with minimum movement of control knob shaft. Extremely dependable long life switches.

SPECIAL TANDEM ASSEMBLIES

Ohmite Rheostats can be mounted with two, three, or more in tandem for simultaneous operation of several circuits by one knob.

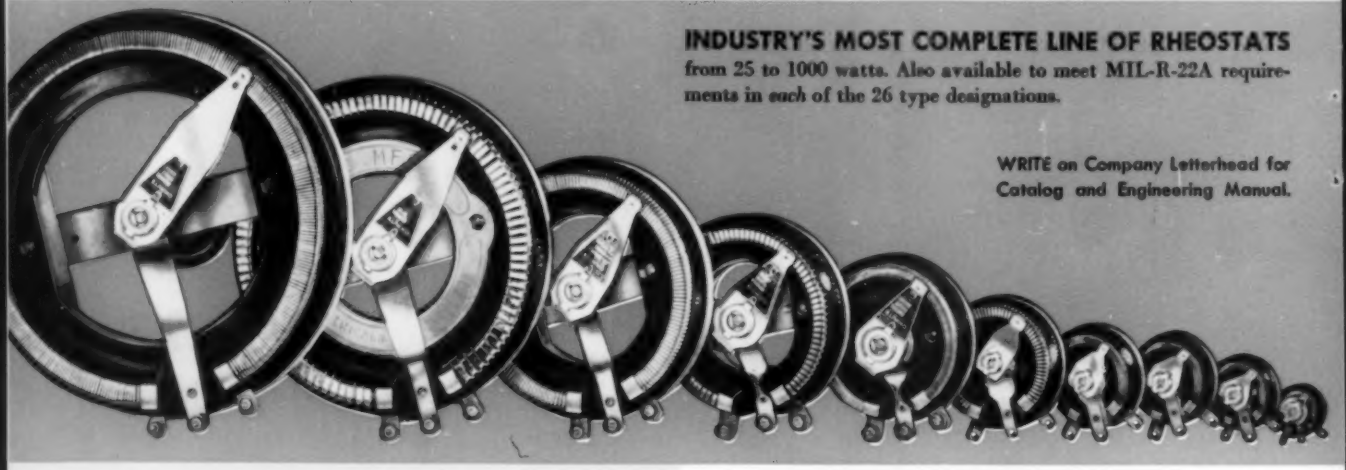


TOGGLE SWITCH

Is operated with a positive snap by the rheostat arm at either end position. Used for heavy-duty applications.

WITH OFF POSITION FEATURES

Opens circuit at high or low resistance position with *snap-action* (illus.); opens circuit at high resistance position with *dead lug* off position; or has *dead section* off position.



INDUSTRY'S MOST COMPLETE LINE OF RHEOSTATS

from 25 to 1000 watts. Also available to meet MIL-R-22A requirements in *each* of the 26 type designations.

WRITE on Company Letterhead for Catalog and Engineering Manual.

RHEOSTATS • RESISTORS • RELAYS
TAP SWITCHES • TANTALUM CAPACITORS

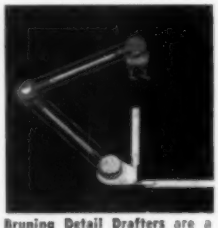
BE RIGHT WITH OHMITE®

OHMITE MANUFACTURING COMPANY, 3611 Howard Street, Skokie, Illinois

"And I Said I'd Never Use a Drafting Machine"

Bruning Track Drafters bring new space-saving efficiency and accuracy to firms that need extra-large drawings. Single-arm and double-arm models offer automatic indexing, double verniers, fast scale changes and up to 84" vertical coverage.

Bruning Counterbalanced Drafters provide unusual speed, accuracy in vertical drafting. Arm lengths available to cover 36" x 60" to 48" x 96" areas.



Bruning Detail Drafters are a smaller, lower priced variation of larger Bruning machines. Ideal for shops, schools, and in the field.

"That Was Before I Tried a Bruning Equipoise Drafter!"

Take a tip from an increasing number of draftsmen who, perhaps like yourself, were reluctant to try any drafting machine or had been disappointed in a conventional type drafter. These men now report: Bruning Equipoise Drafters cut drafting time over conventional equipment up to 40% on most jobs, up to 50% on some structural drawings — beat any other drafting machine they ever tried.

But prove it to yourself! See how fast you'll work with one precision instrument combining T-square, straightedge, triangle, protractor, and scales. Feel how the patented Equipoise mechanism eliminates any drift from gravity, literally makes the drafter "float" into place. Find how easy it is to rotate, turn, and lift this drafter — all with the left hand. At the same time, operate the Touch Control button with your left thumb to set the drafter automatically at any of 24 commonly used 15-degree increment angles. Don't overlook the special scale lock that makes it easy to change the scales, holds the scales rigid.

Your own test will convince you of the superiority of a Bruning Equipoise Drafter. Mail coupon today!

America's Leading Supplier of Engineering and Drafting Equipment.

BRUNING

Offices in 38 cities of the U.S. and Canada.

CHARLES BRUNING COMPANY, INC., Chicago 41, Illinois

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Charles Bruning Company, Inc., Dept. 74-O
4700 Montrose Ave., Chicago 41, Illinois

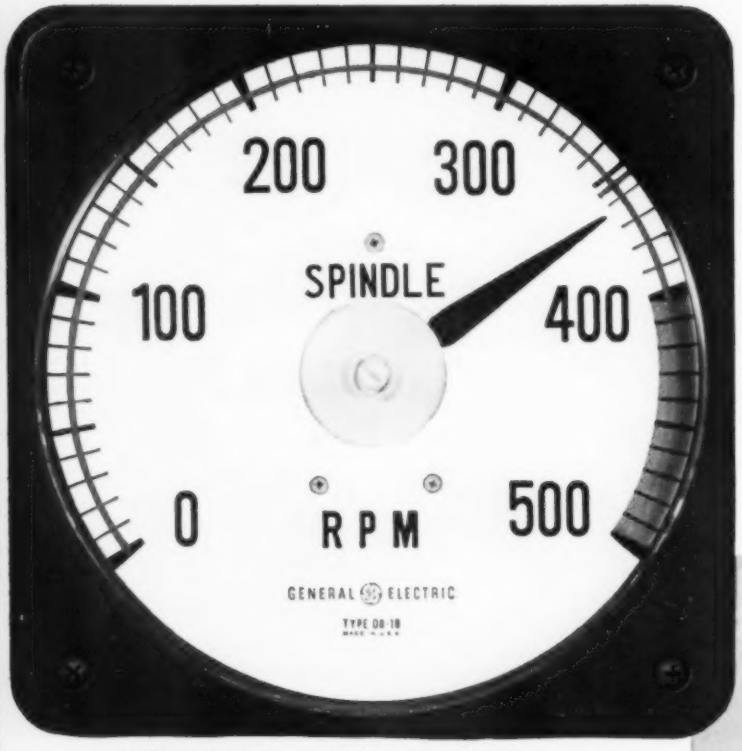
Please send me the free booklet on Bruning Drafting Machines.

Name_____ Title_____

Company_____

Address_____

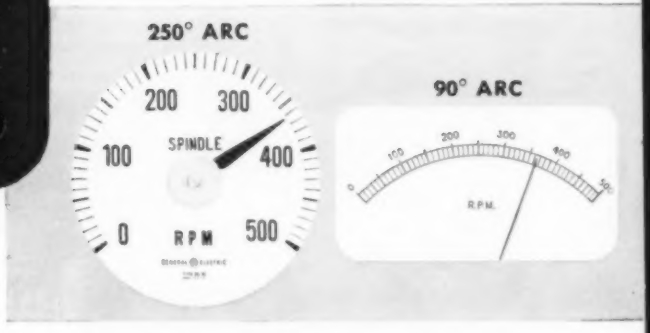
City_____ County_____ State_____

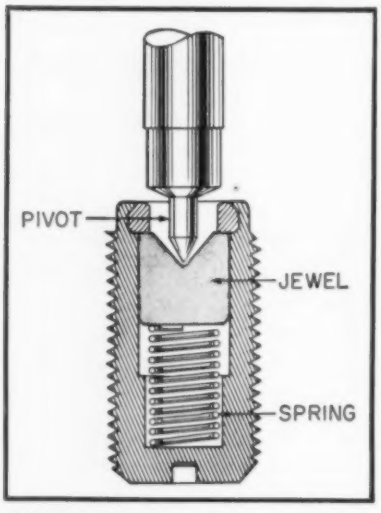


ACTUAL SIZE photo of G-E 4¼" speed indicator shows ease of readability made possible by shadow-proof glass, 250-degree scale, and large numerals. See the difference that the longer scale and larger numerals make (right). This design is also available in an 8¾-inch instrument.

GENERAL ELECTRIC
SPEED-MEASURING SYSTEMS OFFER:

Improved Readability; Shock-Resistant Pivot Design





SHOCK-RESISTANT, G-E long-scale instruments utilize spring-mounted jewels to cushion pressure on pivot points. Bevel-shouldered pivots ride against retainers to help protect against "mushrooming."

Improved readability and sustained accuracy even under difficult conditions of shock and vibration are two major benefits of the long-scale speed-measuring instruments. Used with any of the complete line of General Electric a-c or d-c tachometer generators, these handsome indicators provide a speed-measuring system with features unmatched by other equipment.

SHOCK RESISTING PIVOT DESIGN

Sustained accuracy of reading even under difficult conditions is made possible by the shock resisting spring-mounted jewel and pivot design of these instruments. This construction practically eliminates pivot "mushrooming" and resultant sticky pointer action caused by shock and vibration incurred in high-speed applications.

SYSTEM ACCURACY OF ±1%

All General Electric speed-measuring systems incorporating long-scale instruments are factory calibrated for an accuracy of ±1% of full scale. Any errors that occur in a-c systems due to rectifier aging can be eliminated by periodic adjusting of the rheostat at the base of the indicator, another exclusive feature.

RECORDERS ALSO AVAILABLE

For recording and controlling speed, General Electric also offers a line of electronic, servo-operated, round-chart recorders and recording controllers. Special circuits are available for measuring differential speed, speed ratio, speed deviation from a fixed reference, and the reciprocal of speed or "time in process." For some models, accuracy is as high as 0.1% of measured speed.

For recording only, you can use General Electric's versatile CH recorder with the enclosed, throw-away inkwell that minimizes spilling and eliminates cleaning.

WRITE FOR BULLETINS

For more detailed information, call your nearest General Electric Apparatus Sales Office or write for descriptive bulletins to Section 585-71A, General Electric Company, Schenectady 5, N. Y.

Progress Is Our Most Important Product

GENERAL ELECTRIC

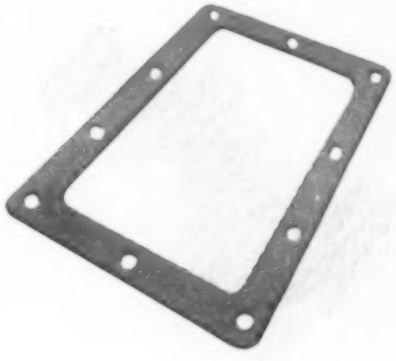
Accopac fiber gaskets offer new high in sealing efficiency

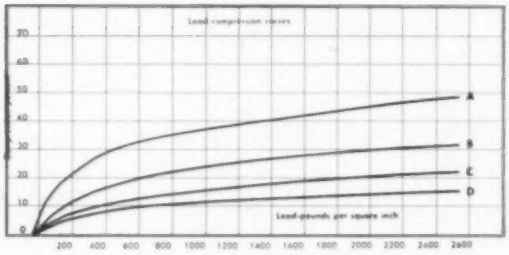
New materials seal at higher temperatures under light or heavy flange loads

The new, expanded line of Accopac® materials brings an entirely new degree of sealing efficiency and dependable performance to a wide range of fiber sheet gasket applications.

Where flange pressures are in the range of 800-2000 psi, there are Accopac compositions that contain cork for added compressibility and sealing efficiency at these relatively low unit loads. For heavy-duty jobs, where flange pressures are 2,000 psi or higher, there are other, more dense Accopac materials that contain no cork.

All Accopac compositions are made by an exclusive patented process, in which individual fibers are coated with a synthetic latex binder before the sheet is formed. This assures uniform distribution of binder and fibers, and the result is a strong, homogeneous material.





A major advantage offered by this process is that Accopac materials have unusual dimensional stability. Accopac gaskets won't shrink or grow in the flange—or . . storage—because their synthetic binders are non-extractable and will not vaporize even at temperatures up to 250° F.

There are Accopac compositions made to meet virtually any combination of operating conditions. The chart below briefly describes various Accopac cellulose fiber materials and shows their characteristics and suggested uses. For more information, write Armstrong Cork Company, Industrial Div., 7007 Irvin St., Lancaster, Pa.

Accopac cellulose fiber gasket materials

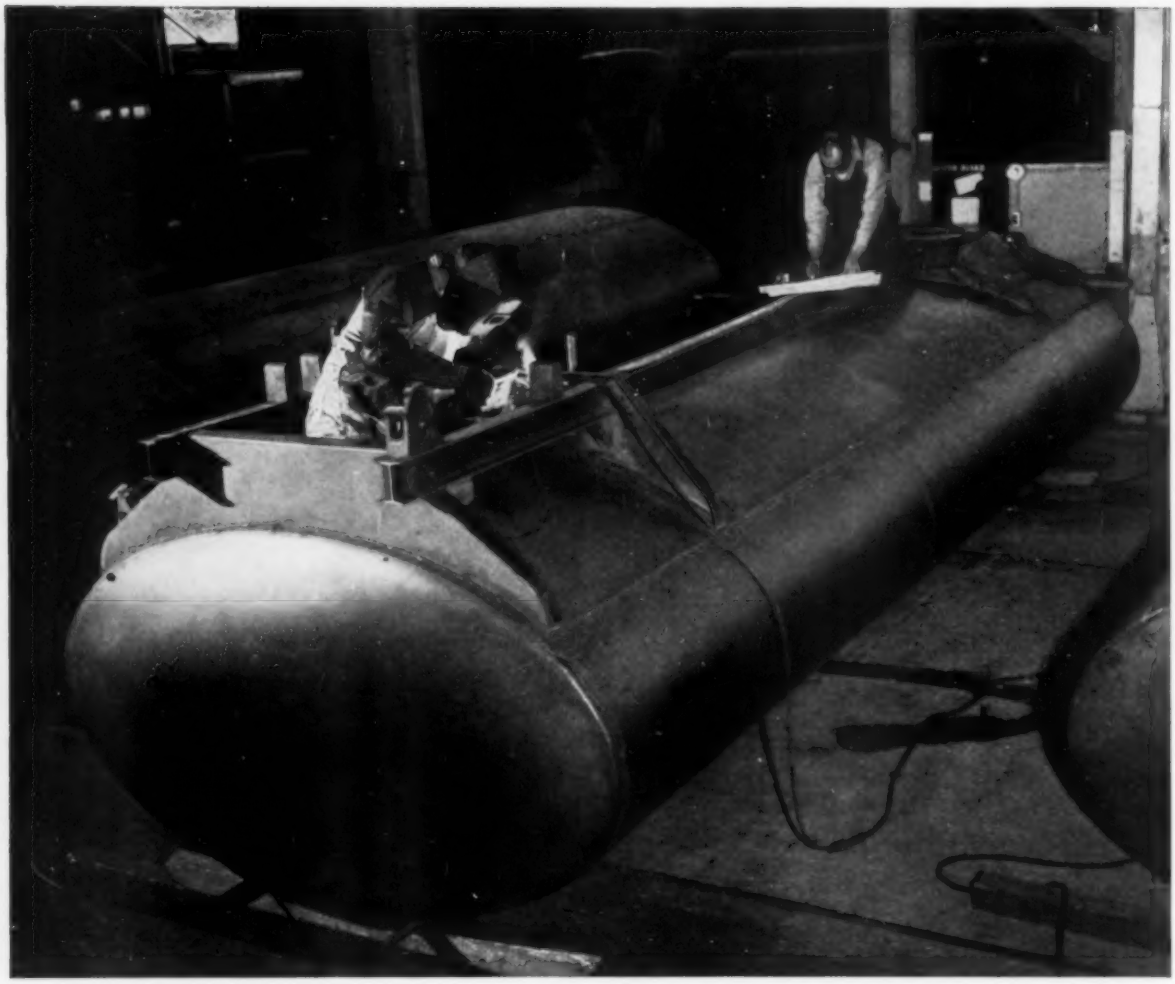
GENERAL CHARACTERISTICS	TYPE	CURVE	COMPOSITION, CHARACTERISTICS, AND USES	COMPRESSIBILITY-% 1,000 PSI	MINIMUM TENSILE AMD (PSI)
FOR FLANGE PRESSURES FROM 800-2,000 PSI For increased sealing efficiency at these relatively low unit loads, there are three Accopac materials that contain finely ground cork. These materials seal under bolt pressures as low as 800 psi and are recommended for applications where flange pressures are up to 2,000 psi and where temperatures do not exceed 250° F.	CS-301	A	Used to seal certain greases, high aniline point oils, water, and other services not involving aromatic fuels. Highly compressible material containing finely ground cork. Styrene-type (Buna S) rubber binder. Underwriters' approved.	30-45	800
	CN-705	A	Generally suitable for sealing lighter petroleum distillates (including gasoline) and water services. Highly compressible. Nitrile-type (Buna N) binder. Underwriters' approved.	30-45	1,000
	CN-808	D	This is a pre-compressed material in which the natural interstices have been closed by pressure. It seals at flange pressures as low as 800 psi. Generally suitable for sealing lighter petroleum distillates and water services. Nitrile-type (Buna N) binder.	5-15	2,200
FOR FLANGE PRESSURES OVER 2,000 PSI For heavy-duty flanges, where bolt pressures are 2,000 psi or higher, there are Accopac materials that contain no cork. These are dense formulations designed to take heavy loads with minimum extrusion and loss of bolt torque. Where temperatures do not exceed 250° F., they offer an economical substitute for compressed asbestos sheet packing.	N-820	C	Very high quality material recommended for heavy-duty flanges where bolt torque loss and extrusion must be held to minimum. Dense composition with low compressibility. Contains mineral filler. Nitrile-type (Buna N) binder.	10-20	3,000
	N-852	B	A low-cost, medium-density material recommended for medium to heavy-duty flanges. Moderate oil resistance. Binder is blend of synthetic rubbers, including nitrile-type (Buna N).	17-27	1,800
	N-854	B	A medium hard, oil-resistant composition for use with high flange pressures. Contains special mineral filler and nitrile-type (Buna N) binder.	15-25	2,500
	D-856	B	Recommended for medium to heavy flange pressures in services where chloroprene-type (neoprene) binder is preferred.	17-27	2,000

*Tested per ASTM D1147-53T

You'll find additional helpful information on the whole line of Accopac fiber sheet gasket materials—including the new Accopac asbestos fiber materials—in this new folder.

Armstrong ACCOPAC

. . . used wherever performance counts



Putting the finishing touches on a 4600-gal tank trailer in the shops of Industrial Steel Tank and Body Works, Berkeley, California. Tank was welded from 12-ga Mayari R sheets.

They use 12-ga Mayari R sheets in place of 10-ga carbon steel

This tank trailer, being assembled in the shops of Industrial Steel Tank and Body Works, Berkeley, California, is a hot-oil carrier to be used in road construction jobs. Formerly made of 10-ga carbon steel sheets, the tanks are now welded from 12-ga Mayari R high-strength, low-alloy steel sheets with substantial savings in deadweight.

"We have wide acceptance of our hot oil tanks made of 12-ga Mayari R," say the Industrial Tank people, adding: "In working with Mayari R there are no welding problems. It is easy to work with and it is a good, tough piece of material for the job, with terrific savings because of the lighter-weight sheet we can use."

More and more manufacturers of tankers like this, as well as buses, walk-in panels, dump trucks and flat-beds are turning to Mayari R. Shop men find they can weld, work and form Mayari R without special equipment or techniques. Owners like the fact that Mayari R holds paint much longer than carbon steel, and resists atmospheric corrosion 5 to 6 times better.

If your product is one which might benefit from the superior properties of Mayari R sheets, a Bethlehem representative will be glad to discuss it with you. You can reach him through the nearest Bethlehem district sales office.

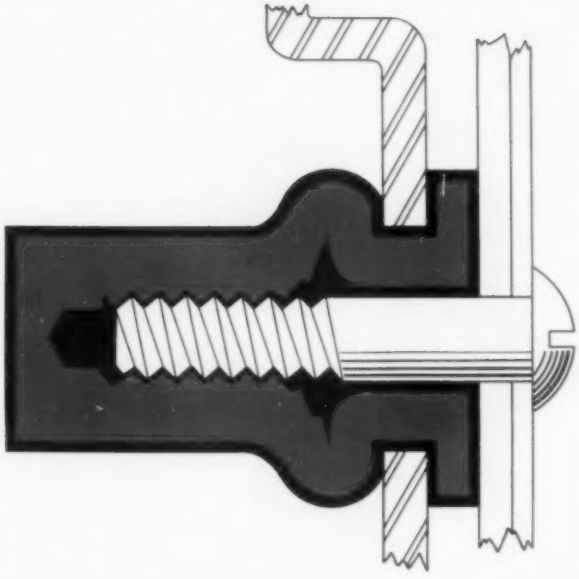
BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation
Export Distributor: Bethlehem Steel Export Corporation

Mayari R...High-Strength, Corrosion-Resisting Steel

BETHLEHEM STEEL

B.F.Goodrich® Rivnuts
boost profits by cutting assembly costs



RIVNUTS PROVIDE 6 THREAD NUTPLATES THAT STAY PUT, ELIMINATE WELDING, SPEED ASSEMBLY

Suppose you have to fasten a porcelainized sheet metal top to a frame assembly. You want to do the job as quickly as possible to keep down your production costs. You also want to be able to remove the top easily for servicing.

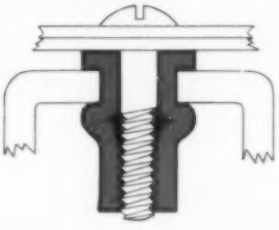
This is the problem that faced the manufacturer of automatic washing machines. He solved it by using Rivnuts, the *only* one-piece blind nutplate with threads. Upset from *one* side by *one* worker in seconds, Rivnuts provided a nutplate—solid as a rivet—with six clean threads for screw attachment. No matter how many times the top is removed, Rivnuts stay firmly in place with threads intact.

Before selecting Rivnuts, this manufacturer considered several conventional fastening methods. None of them appeared satisfactory. Bolts would hold the top, but the nuts would drop down inside if the top were removed. Self-tapping screw might tear loose. And the cost of installing welded nutplates was prohibitive—might have caused warping of the thin sheet metal.

By using Rivnuts, time was saved two ways: in factory assembly and in maintenance later on. B. F. Goodrich Rivnuts have speeded up thousands of similar operations and helped provide better, stronger products with greater eye appeal, beauty and sales appeal. No doubt they can do the same for you. Just write B. F. Goodrich Aviation Products outlining your problem. Our engineers will determine which Rivnut will do the job.

RIVNUTS SOLVE THE PROBLEM WHEN OTHER FASTENING METHODS FAIL

RIVNUTS

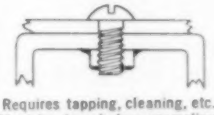


Installed from one side. Gives the strength of 6 clean threads. Provides firm, accurate nutplate. Installed in seconds by one person after enameling.

SELF-TAPPING

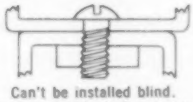
No structural strength. Tears loose easily. Lacks quality. Limits refastening.

WELDING



Requires tapping, cleaning, etc. Must be done before enameling. Gives fewer threads. Costs too much.

NUTS



Can't be installed blind. Drop down inside during removal. Difficult to install.

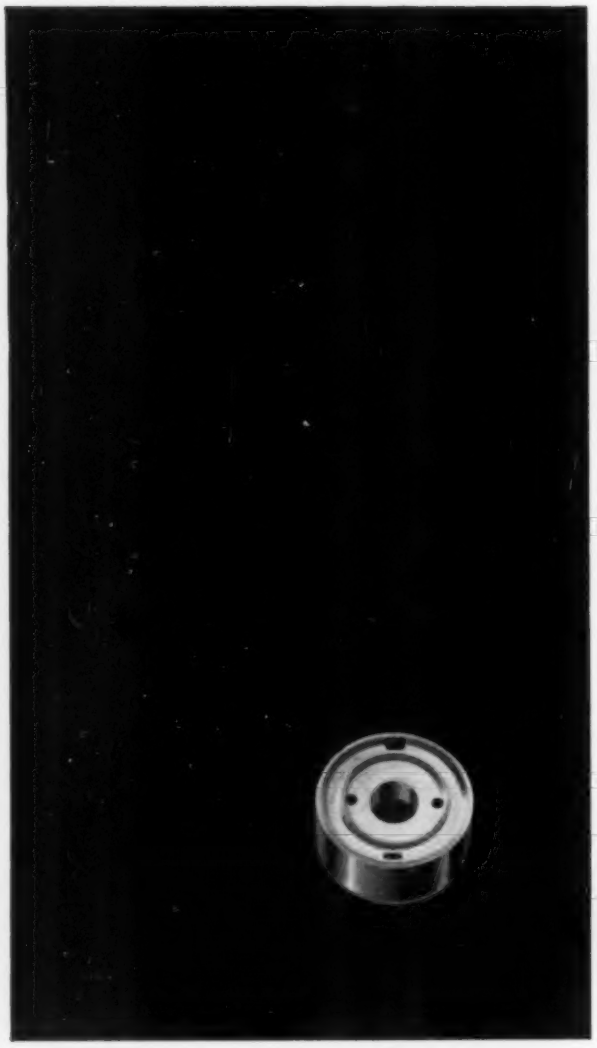
SEND NOW FOR FREE RIVNUT DEMONSTRATOR

Demonstrates with motion how you can use Rivnuts to fasten *with* and *to*. Explains construction, simplicity of installation. Get your free copy by writing to: B. F. Goodrich Rivnuts, Department PE-77, Akron, Ohio.

B.F.Goodrich

B.F.Goodrich Aviation Products

a division of The B. F. Goodrich Company, Akron, Ohio



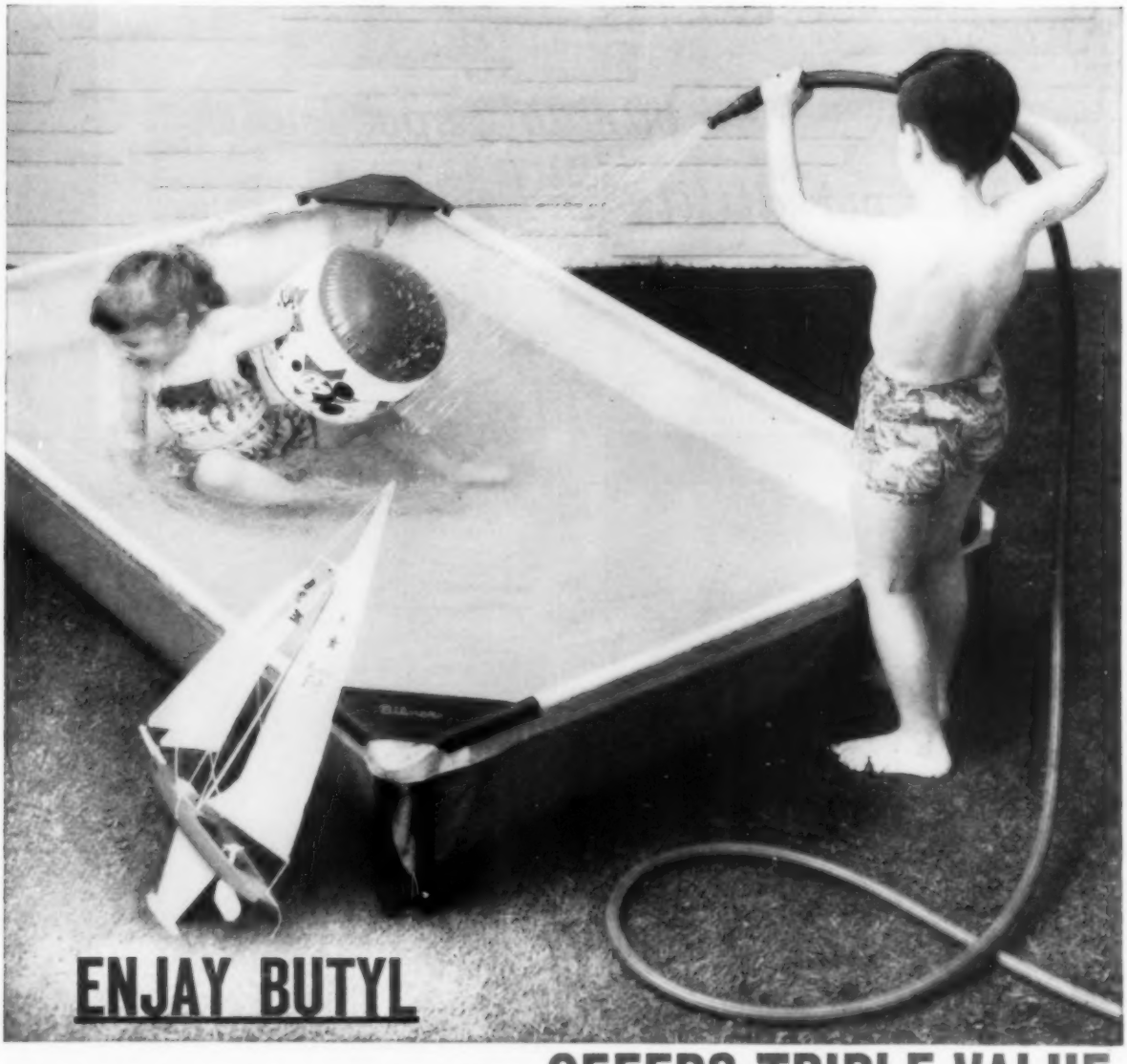
How *small* can variations be in metal powder parts?

The metal powder shock absorber piston on the left is a basic design. Hundreds of thousands exactly like it are made every year. Those on the right match it precisely—in diameter and length. And they, too, are made in vast numbers. But each one has its own variations, as examination will show, to suit it to the weight and ride characteristics of a particular vehicle. Regardless of the similarity or variation, all of these parts are made inexpensively of metal powder with no machining and no wasted stock. In every case, closer-than-ever tolerances are maintained.

Moraine Products also produces: Moraine Power Brakes—Delco hydraulic brake fluids, brake assemblies, master cylinders, wheel cylinders, and parts—Moraine friction materials—Moraine-400 and M-100 automotive engine bearings—self-lubricating bearings and porous metal filters—rolled bronze and bi-metal bushings.

Another General Motors Value

Moraine Products
Division of General Motors, Dayton, Ohio



today's super-durable rubber OFFERS TRIPLE VALUE

Performance! Versatility! Economy! In all three, Enjay Butyl is the world's outstanding rubber value. In laboratory tests, and in a wide variety of applications, Enjay Butyl has demonstrated its tremendous resistance to weather, sunlight, moisture, tear, impact, chipping and cracking . . . properties that set Enjay Butyl-made products apart as outstanding performers.

Children's wading pools, hot materials conveyor belts, garden hose . . . in these, and many other rubber products, Enjay Butyl out-performs and outlasts *all other* types of rubber, synthetic *or* natural. *Low-in-cost* and *immediately available* in regular and non-staining grades for white and colored applications, this truly wonder rubber may well be able to cut costs and improve performance in *your* product. For further information, and for expert technical assistance, contact the Enjay Company.

ENJAY BUTYL

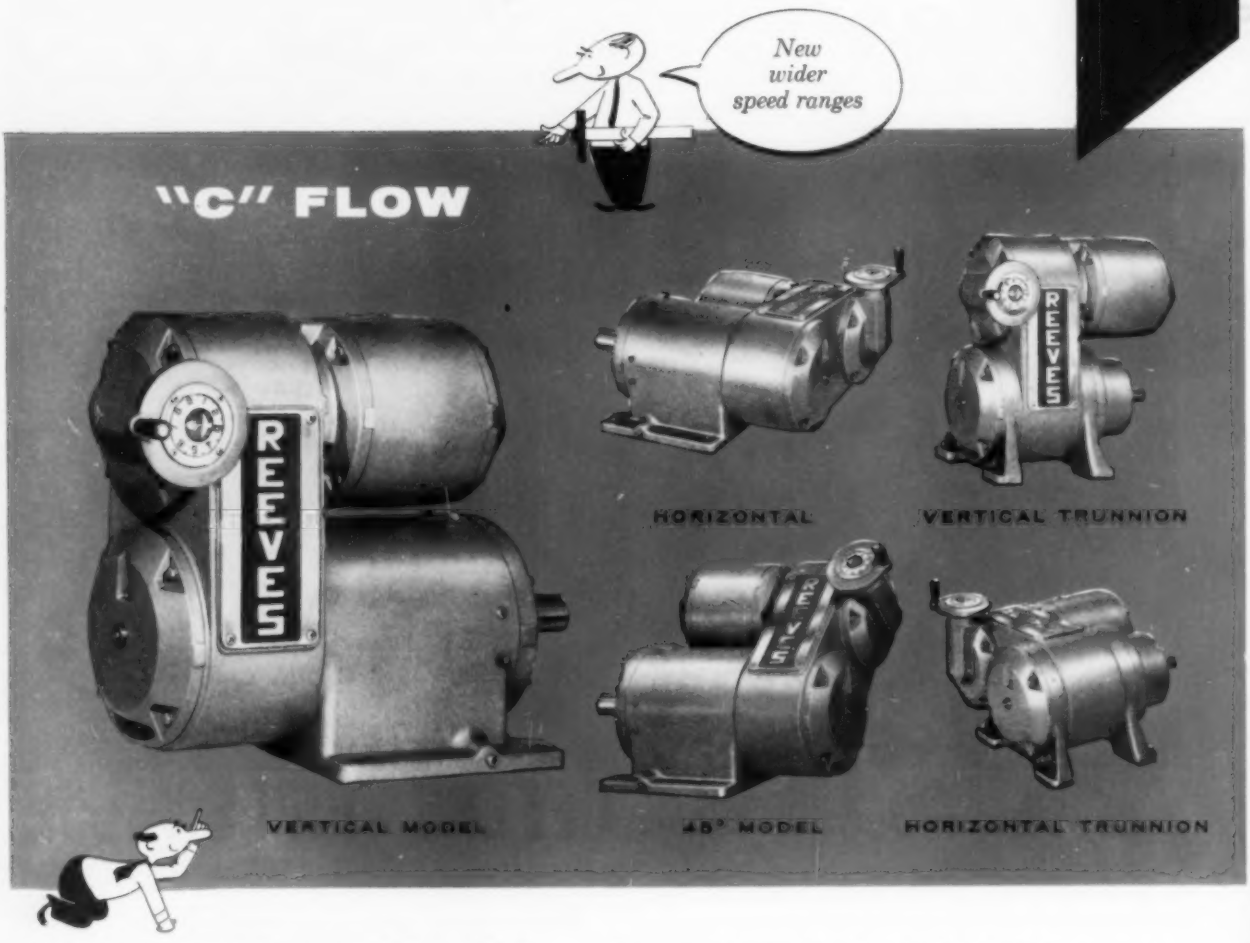
Enjay Butyl is the greatest rubber value in the world . . . the super-durable rubber with *outstanding* resistance to aging • abrasion • tear • chipping • cracking • ozone and corona • chemicals • gases • heat • cold • sunlight • moisture.

ENJAY *Pioneer in Petrochemicals*

ENJAY COMPANY, INC., 15 West 51st Street, New York 19, N. Y.

Akron • Boston • Chicago • Los Angeles • New Orleans • Tulsa

variable speed with new versatility and performance



A triumph of new Motodrive design . . . inside and out

New REEVES Vari-Speed Motodrives, sizes 200 and 300, are complete variable speed power packages, built with compactness and precision, to give improved performance on installations 1 through 5 hp.

The new sizes are designed in two styles—"C" flow and "Z" flow. In each style, there are several different models and reducers with increased capacity in single, double or triple stages.

The flexible design permits hundreds of combinations . . . space-saving, space-fitting *standard* assemblies to meet most installation requirements.

The handwheel control location can be rotated to optional positions for greater operating convenience; extra precision of control is available with the addition of one or more REEVES accessories or modifications.

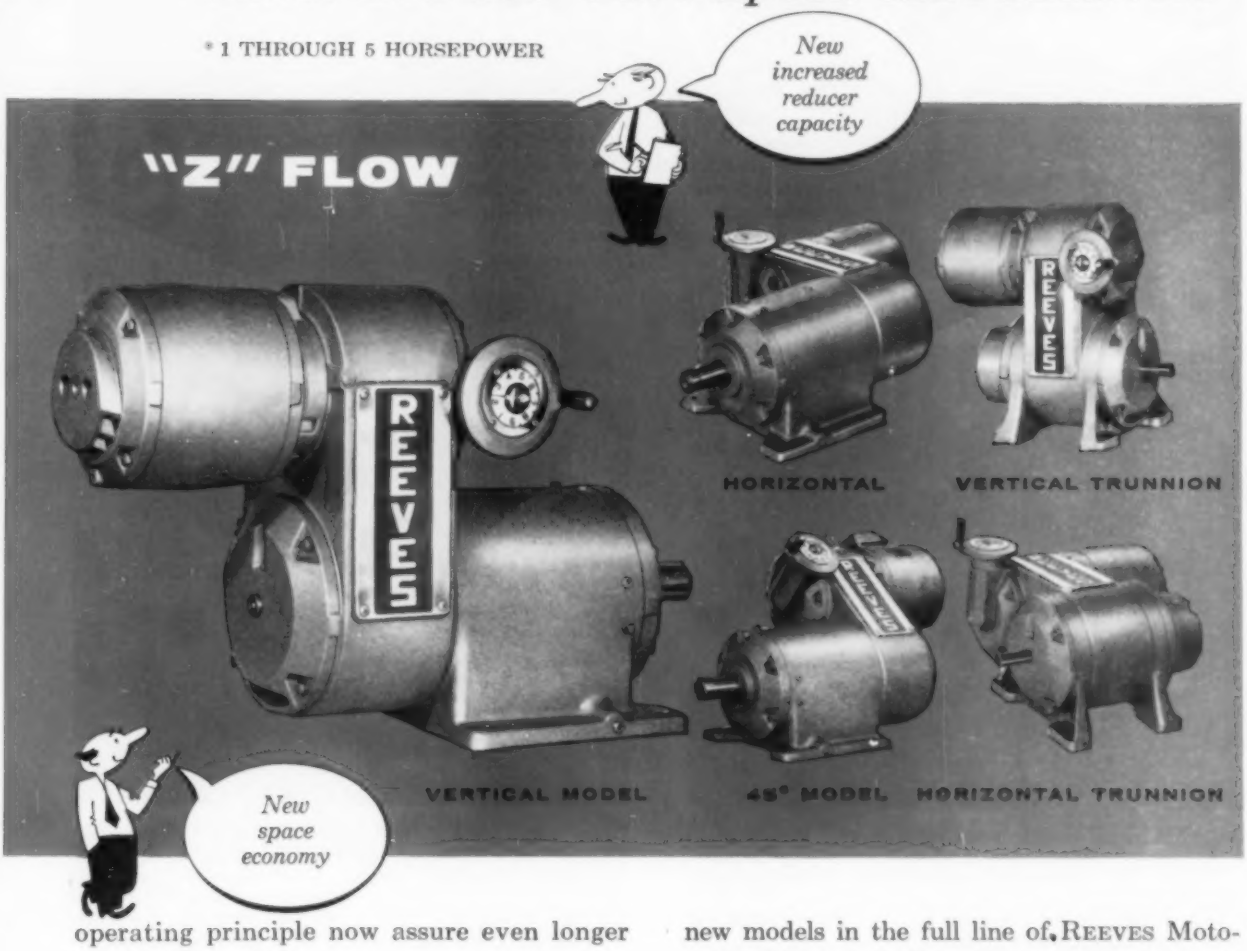
Refinements to the time-tested REEVES

NEW

REEVES®

*Sizes 200-300 Vari-Speed MOTODRIVES**

* 1 THROUGH 5 HORSEPOWER



operating principle now assure even longer trouble-free service.

New disc assemblies permit wider output speed ranges . . . discs are pre-aligned . . . pre-loaded spring maintains correct belt tension for longer belt wear . . . *exclusive* "close-grooving" lubrication assures free sliding discs . . . new Metermatic system automatically lubricates the motor and variable shaft bearings.

Sizes 200 and 300 are versatile, hard-working new models in the full line of REEVES Motodrives which provide instant and accurate variable speed control on ¼ through 40 hp. applications.

Complete details, dimensions, illustrations and prices on assemblies, modifications and accessories are in Catalog K31-M571. Write for your free copy today.

REEVES PULLEY COMPANY

Division of **RELIANCE** ELECTRIC AND ENGINEERING CO.

Columbus, Indiana

Seeburg designers choose P-K® screws

to match the fastener to the job!

Joseph Kamys, engineer, J. P. Seeburg Corporation, Chicago, manufacturers of coin operated phonographs says, "Seeburg standards demand attention to every detail—quality workmanship and materials throughout. With Parker-Kalon screws, we can match the fastener to the specific application—be sure of dependable results."

Attachment of metal base molding and kickplate to a Seeburg cabinet, in a metal-to-wood application. "Rather than use ordinary wood screws, we power-drive P-K Self-tapping Type-A," says Mr. Kamys. "Holding power is far better, there's less chance of wood splitting, and fewer rejects at inspection."

Here, metal rims of two high-frequency speakers are fastened to a formed, one-piece, plastic housing. "In this metal-to-plastic application we have not only the problem of possible plastic breakage, but the fastener used must be highly resistant to vibration. We find P-K thread-forming Type-Z screws highly satisfactory."

If you are designing a new product or new model, it will pay you to talk with a Parker-Kalon Field Engineer. He can help in the selection of proper fasteners, can often suggest ways to speed production—cut costs. You can contact him through your local Parker-Kalon Industrial Supply Distributor.

***PARKER-KALON DIVISION,** General American Transportation Corporation, Manufacturers of Self-tapping Screws, Socket Screws, Screwnails, Masonry Nails, Wing Nuts and Thumb Screws.*

Sold Everywhere Through Leading Industrial Distributors. Factory: Clifton, New Jersey—Warehouses: Chicago, Illinois, Los Angeles, Calif.

PARKER-KALON®
fasteners

STAINLESS STEEL MAKES THE DIFFERENCE

...its effect on modern castings

Through modern casting techniques, you can get all the useful qualities of stainless steel in everything from small intricate parts to large precise shapes.

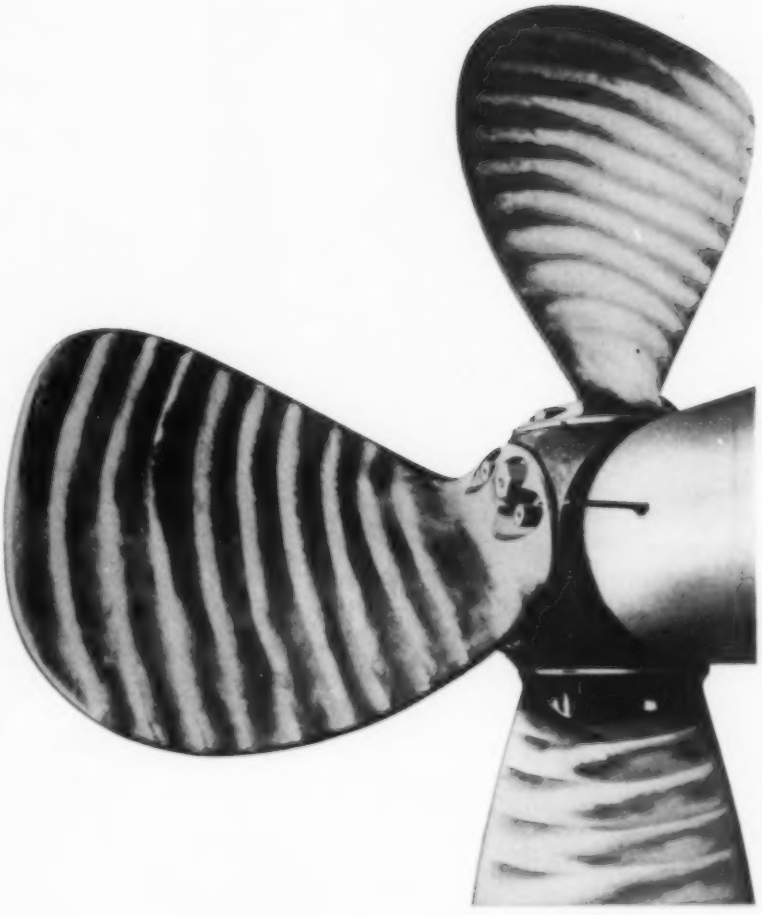
For example, stainless steel is giving giant ship propellers new toughness and resistance to corrosion and erosion. This means that peak speeds and efficiency can be sustained much longer. The "work hardening" property of stainless steel minimizes wear and cuts operating risks, too.

This combination of stainless steel and casting techniques gives design engineers a powerful tool to improve the effectiveness and "sales appeal" of their designs. For more information, write: ELECTRO METALLURGICAL COMPANY, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, N. Y.

METALS DO MORE ALL THE TIME ...THANKS TO ALLOYS

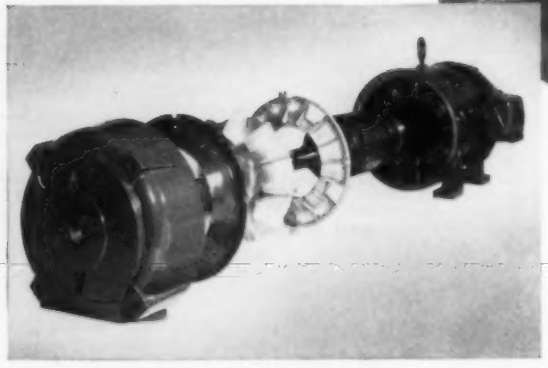
Electromet
FERRO-ALLOYS AND METALS

UNION CARBIDE

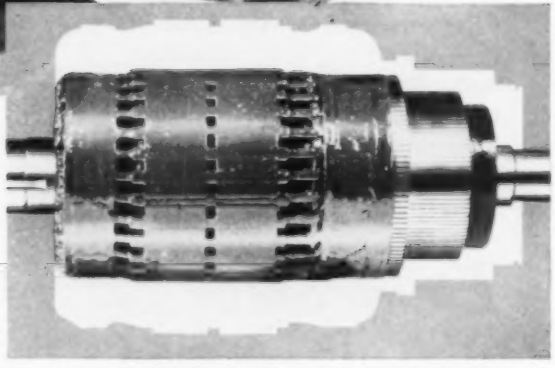


Ingeniously constructed of four blades and hub, cast separately and bolted together, this stainless steel propeller defies corrosion and erosion . . . maintains "original design" efficiency.

The terms "Electromet" and "Union Carbide" are registered trade-marks of Union Carbide Corporation.



NEW CONTROLLED VENTILATION—pushes air through the motor from drive end to commutator end, opposite to the ordinary direction. Armature cooling is increased... harmful brush dust created at the commutator is blown out of the motor.



NEW LEVEL OF RESPONSE—Improved ventilation makes up to 55% lower armature inertia possible without sacrifice in capacity. Life-Line "H" gives the fastest accelerations and regulating speed changes for more and better production.

Westinghouse *Life-Line H* with silicone insulation

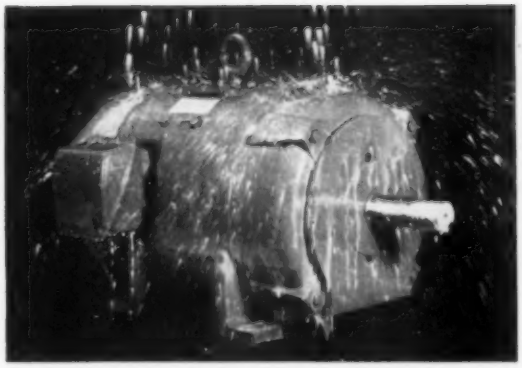
FASTEST RESPONSE OF ANY STANDARD INDUSTRIAL MOTOR

Life-Line® "H" Backs Up Lowest Inertia With High Commutating Ability for Increased Production

Highly responsive drives are essential to fast automatic processing. No other d-c drive provides as fast speed changes as the Westinghouse Life-Line "H".

Efficient controlled ventilation makes possible the long, slim design of the Life-Line "H" armature, reducing inertia as much as 55% without sacrificing any capacity. 35% increase in commutating ability backs up this lowest inertia to produce the fastest response available in standard industrial d-c motors today.

In addition, the new Life-Line "H" with silicone insulation, offers many dividends in long-term dependability and minimum maintenance. For all the facts about Life-Line "H" call your Westinghouse sales engineer. Or, write Westinghouse Electric Corporation, 3 Gateway Center, P. O. Box 868, Pittsburgh 30, Pa. Ask for B-7056. J-21991-C

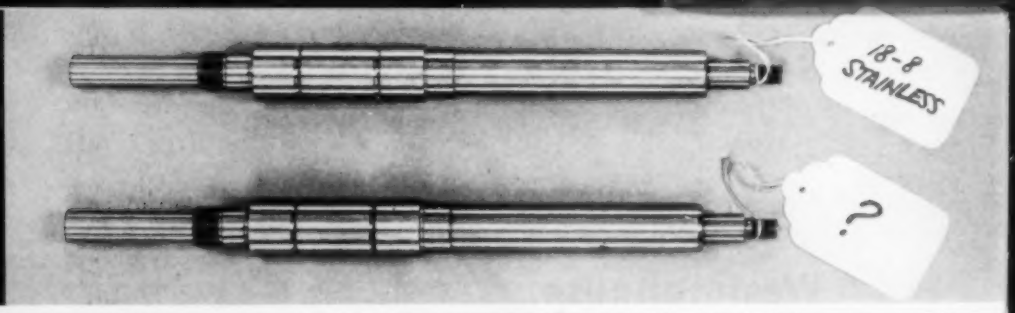


NEW HOUSING DESIGN—provides maximum protection—eliminates need for splashproof enclosures in many cases. All access openings are sealed with covers . . . single ventilation opening in each bracket faces directly down.

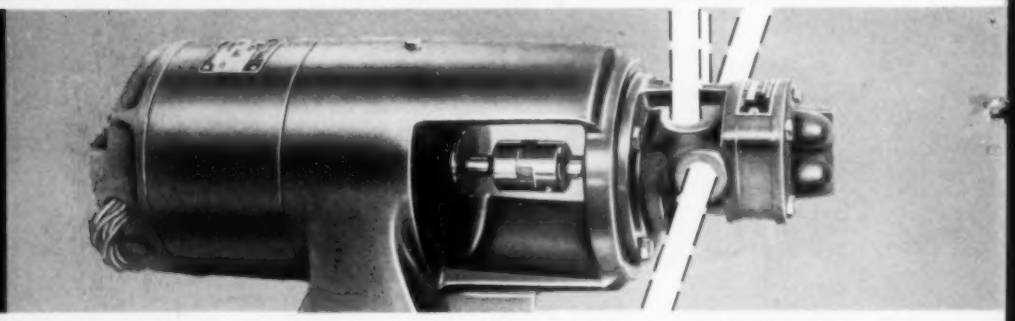
YOU CAN BE SURE...IF IT'S

Westinghouse

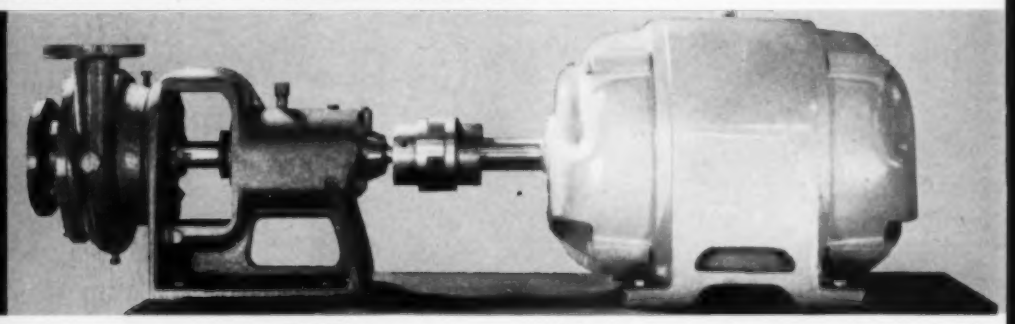
1. What's more "stainless" than "stainless steel"?



2. What's the newest in rotary pump hook-ups?



3. It comes in 70,480 combinations. Can you name the line?



4. Whose pumps would you have found in the Merrimac? Monitor?

WHAT'S YOUR P.Q.? (PUMP QUOTIENT)

1. *Answer:* Worthite*. Worthite is Worthington's super stainless steel for chemical pumps. Containing over 50% more alloy than 18-8 stainless, Worthite gives one third greater corrosion coverage for just a few cents more per pound. Bulletin W-350-B4 has complete details about Worthite.

2. Dual suction and discharge openings are the newest idea in rotary pumps. Available on the new Worthington Monobloc Rotary, they allow a choice of 28 different piping arrangements. In addition to simplified hook-ups, the new Worthington Monobloc Rotaries have many new convenience features such as standardized flange and shaft diameters to eliminate alignment. Flexible coupling allows rapid pump replacement without disturbing motor. For more information write for Bulletin W-484-B1.

3. The pump you see is just one of the 70,480 combinations available in Worthington SESC line. An abbreviation for "Standard End Suction Centrifugal," SESC pumps are the most versatile, most flexible you can buy. They give you a choice of 5 types of liquid ends, 4 materials of construction, 2 shaft sealing methods and 5 different drives. Write for Bulletin W-300-B4.

4. Even way back in 1862, engineers appreciated the value of pumps built by Worthington. Both the Merrimac *and* the Monitor were equipped with Worthington pumps. Today as then, whenever men must move liquid, they turn to the company with a reputation for reliability. Worthington Corporation, Harrison, New Jersey. PC. 7.14

*A high nickel, high-chromium, corrosion resistant alloy steel. Trademark Reg. U. S. Pat. Off.

WORTHINGTON

JULY
1957

Plastiatrics

DOW'S CLINICAL APPROACH TO HEALTHY PLASTICS APPLICATION

MOLD RIGIDITY CRITICAL FACTOR IN INJECTION MOLDING

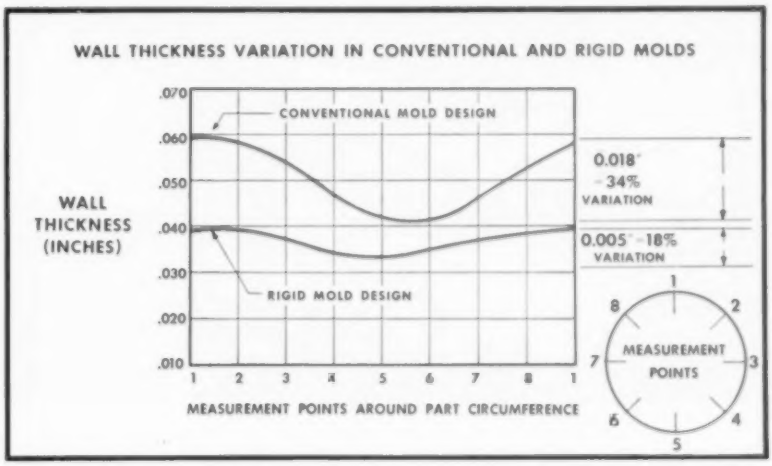
RIGID MOLD DESIGN HELPS MAINTAIN CLOSE DIMENSIONAL TOLERANCES ON THIN-WALLED MOLDINGS

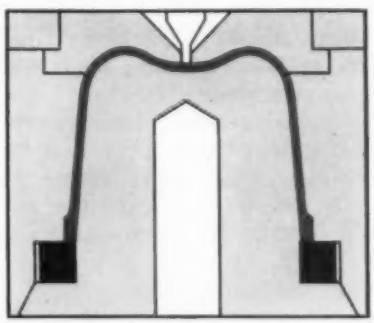
Trends in the injection molding industry indicate the use of larger thin-walled moldings which require closer dimensional tolerances. Research in the Dow Plastics Technical Service Laboratories has shown that these complex pieces must be made in molds with maximum rigidity. To prevent bending or bulging often caused by high plastic pressure in the mold, new design techniques were investigated. Massive design alone is not enough to prevent this condition.

It was found that individually located cores and cavities are more satisfactory than those located by guide pins in multiple cavity molds. Individual location by the use of tapered surfaces or wedge blocks proved to be more effective in maintaining consistent results. Warpage and dimensional change in the mold were minimized by careful heat treating procedures.

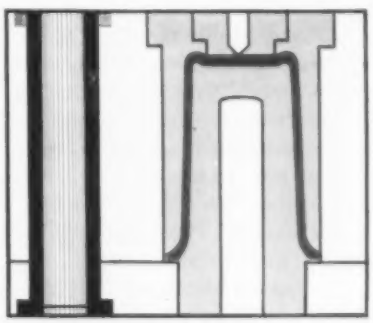
Under the direction of Dow Plastics Technical Service, Plastiatrics studies and research continue in this and similar areas in an effort to find practical solutions to problems in plastics engineering. Determining the factors that contribute to rigid mold design is just one of a series of such studies.

For your copy of "The Importance of Mold Rigidity in Injection Molding", write, THE DOW CHEMICAL COMPANY, Midland, Michigan, Plastics Sales Department PL 1544G.





RIGID DESIGN



CONVENTIONAL DESIGN

As shown in the illustration above, a tapered locating surface brings the core and cavity into alignment more effectively than the guide pin method. Even a slight shift in the alignment could cause a very significant variation in the wall thickness of thin-walled containers. These shifts are minimized by using a tapered locating surface.

AMERICA'S FIRST FAMILY OF POLYSTYRENES

GENERAL PURPOSE
- STYRON 666
- STYRON 665 (Extrusion)
- STYRON 688 (Easy Flow)
- STYRON 689 (Easy Flow)

HIGH IMPACT
- STYRON 475
- STYRON 777 (Medium Impact)
- STYRON 440 (Heat Resistant)
- STYRON 480 (Extra-High Impact)

HEAT RESISTANT
- STYRON 683
- STYRON 700

YOU CAN DEPEND ON DOW

MORE ABOUT THE GARLOCK 2,000

Garlock "makes the grade" with Galion... for over 30 years

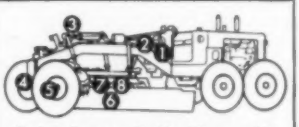
Now celebrating their 50th Anniversary, the Galion Iron Works and Mfg. Co., of Galion, Ohio is a leader in its field, and Galion Road Rollers and Motor Graders enjoy a reputation for long life and easy operation. For 30 years Garlock CHEVRON* Packings have been selected for the hydraulic cylinders of both Galion Road Rollers and Motor Graders. In fact, all eight models of the Motor Grader use CHEVRON Packings exclusively on hydraulic cylinders operating the blade, leaning front wheel, booster steering and various attachments.

The distinctive and exclusive CHEVRON design is extremely sensitive to pressure changes and ideally suited to use in shallow stuffing boxes. As pressures increase the CHEVRON Packing Rings automatically tighten to prevent leakage. As pressures decline the CHEVRON Rings instantly ease off permitting free operation without leakage. That's why cylinders using CHEVRON Packings require minimum attention and maintenance.

Exclusive CHEVRON is one more part of "the famous Garlock 2,000"... two thousand different styles of packings, gaskets, and seals for every need—the only complete line. It's one reason why your Garlock representative can provide you with unbiased recommendation. Call him today or write for CHEVRON Folder AD-115.

THE GARLOCK PACKING COMPANY, Palmyra, N.Y.

For Prompt Service, contact one of our 30 sales offices and warehouses throughout the U.S. and Canada.



Garlock CHEVRON Packing Rings used in 8 hydraulic cylinders on Galion Motor Graders:

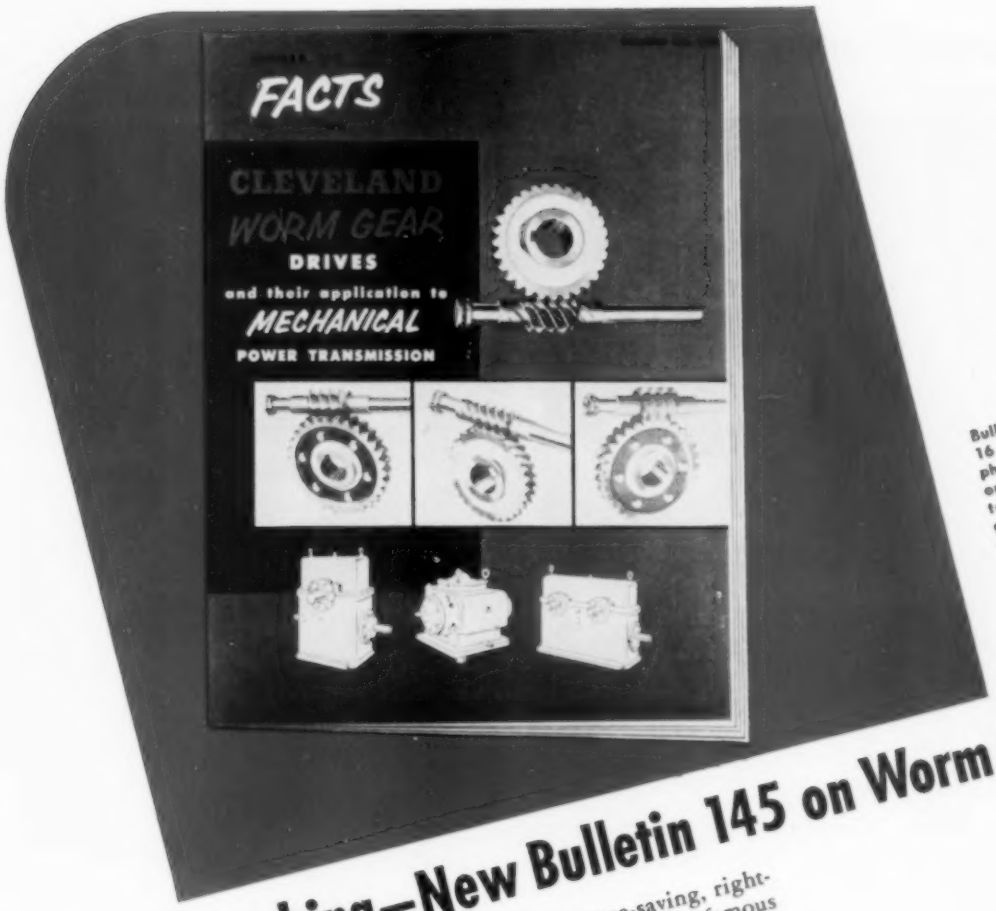
1. Left Blade Lift Cylinder
2. Right Blade Lift Cylinder
3. Scarifier Cylinder
4. Leaning Wheel Cylinder
5. Booster Steering Cylinder
6. Moldboard Shift Cylinder
7. Tilt Moldboard Cylinder Right
8. Tilt Moldboard Cylinder Left

This design is entirely different from ordinary V-type packing. CHEVRON has an exclusive construction which assures the automatic action for which it is designed. Also permits the use of less packing in shallower stuffing boxes.

GARLOCK

Packings, Gaskets, Oil Seals, Mechanical Seals, Rubber Expansion Joints, Fluorocarbon Products

*Registered Trademark.



Bulletin 145 gives you 16 fact-filled pages of photographs and data on standard and custom-designed worm gear speed reducers and worm gearing components for built-in drives.

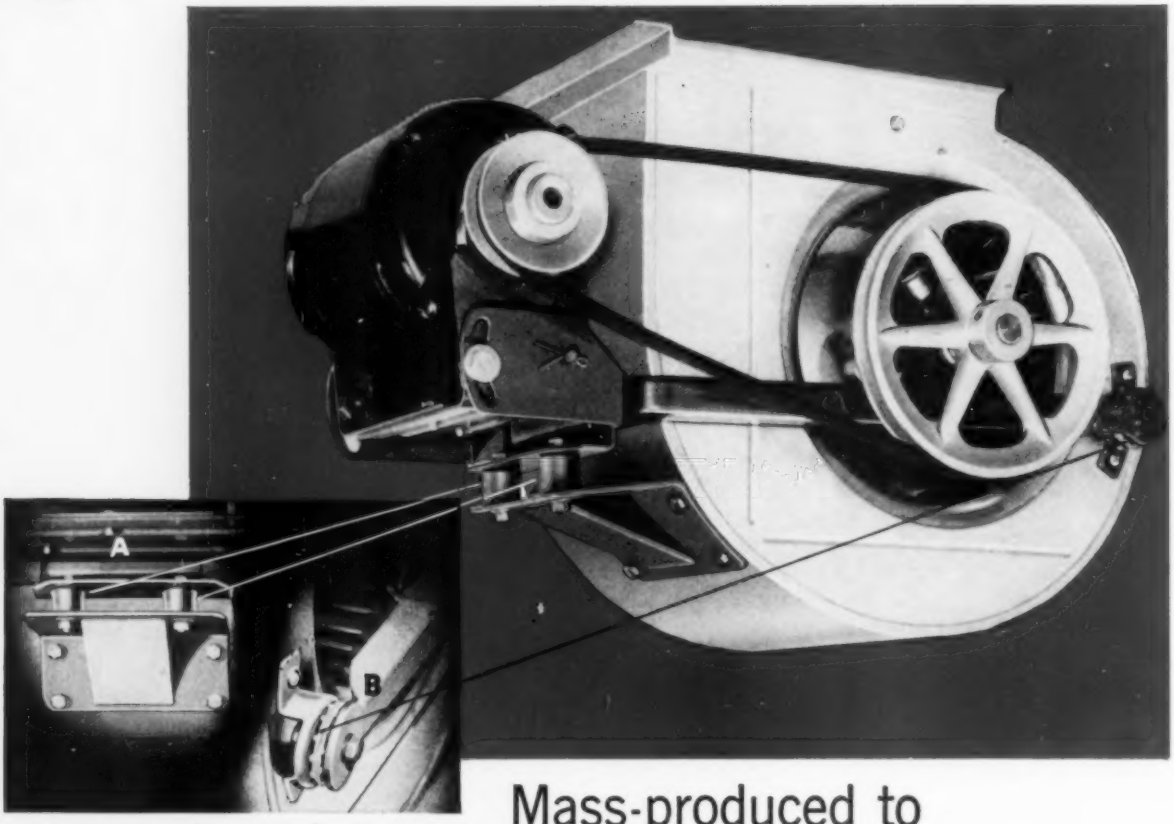
Yours for asking—New Bulletin 145 on Worm Gearing

WHENEVER you want a safe, space-saving, right-angle drive, you specify Cleveland. This famous worm-gear drive transmits power uniformly, smoothly, dependably, under even the most severe operating conditions, for a lifetime of trouble-free service. Clevelands actually improve with use. Thousands of units outlast their driven machines.

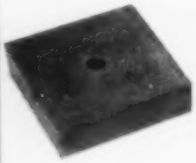
To know what Cleveland best meets any need—for speed reducer or worm-gear set—standard or special—write for new Bulletin 145. Just off press, it will bring your file up to date on this ever more popular drive. The Cleveland Worm & Gear Company, 3279 E. 80th St., Cleveland 4, O.

Affiliate: The Farval Corporation, Centralized Systems of Lubrication. In Canada: Peacock Brothers, Limited.

ENGINEERED RUBBER PRODUCTS

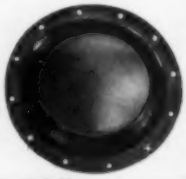


U. S. Molded Shock Mounting for shock absorption when shipping delicate instruments. An electric typewriter manufacturer, for instance, has cut down shipping damage to ½% and cut packaging costs considerably. Improved rubber-to-metal bonding permits their re-use.



U. S. Molded Drop Forge Mounting in service for over 13 years—absorbed *80 million* blows of almost 1600 lbs. force each without wearing out—removed only when steel retaining pins had corroded.

U. S. Molded Diaphragm for controlling liquid flow through motor valves. Offers high burst resistance, retention of molded shape under high pressures, and exact fabric placement.



Mass-produced to exacting specifications

U. S. Rubber Molded Mountings and Connectors help keep blowers operating at "whisper silence".

A well-adjusted system for a forced warm air furnace requires that all vibration and noise be kept to an absolute minimum. In this leading "sulky" type blower, the entire moving parts assembly floats on a cushion of U. S. Molded Rubber Mounts (A) and firm, but movement-free, U. S. Rubber Finger-Flex Connectors (B). In this manner, all mechanical vibrations are isolated—the blower operates in silence.

U. S. Rubber Molded Mountings and Connectors were selected because of their ability to retain "molded in" shape during their entire long life and for the economy they provide.

Yet, this is only one of hundreds of applications wherein U. S. Engineered Rubber Products *do jobs no other material can do.* "U. S." engineers will help you solve any molded rubber problem. Contact us at Rockefeller Center, New York 20, N. Y. In Canada, Dominion Rubber Co., Ltd.

Mechanical Goods Division

United States Rubber

need floats?

Name the way you want them!

MATERIAL_____
SHAPE_____
SIZE_____
PRESSURE_____
QUANTITY_____
MORE INFO_____

*Your Name*_____
*Title*_____
*Company*_____
*Address*_____

See below for details
Fill in blanks, tear out, and mail to:
W. H. NICHOLSON and COMPANY
Wilkes-Barre, Pa.

Nicholson can deliver precision welded floats —made to your specifications—to fit your production schedule. Use the above form to tell us how you want them.

Here are the standard specs:

- **MATERIAL**—steel floats with chromium, cadmium or copper plating—with sandblast or pickled finish . . . stainless steel and Monel floats—rough-buffed, polished or with welds ground smooth and highly finished.
- **SHAPE**—spherical, elliptical, cylindrical.
- **SIZE**—from 2 inches to 14 inches diameter.
- **PRESSURE**—from vacuum to 4800 lbs.
- **QUANTITY**—as many as you need.

These high tensile strength floats have exceptional resistance to pressure and corrosion. Float halves are die-formed, with inward rolled edges—not spun, laminated or electrodeposited.

Today, thousands of Nicholson floats are in service—most as buoyancy mediums . . . many as fluid chambers and pressure vessels. Write for details about the full Nicholson line.

W. H. NICHOLSON AND COMPANY, 12 OREGON ST., WILKES-BARRE, PA., *Sales and Engineering offices in 98 principal cities.*

NICHOLSON
of Wilkes-Barre

Always, at SKF, you will receive unbiased advice

because

– All four basic types of anti-friction bearings are available from **SKF**.

because

– They offer an extraordinarily wide range of sizes and combinations to meet virtually any requirement.

because

– Their long experience in the widest variety of bearing applications is your assurance of receiving sound recommendations.

because

– Thousands of manufacturers have been using the **SKF** Bearing Advisory Service for many years – always with good results. This dependable service is available to you, too. 7754

SKF®

EVERY TYPE–EVERY USE

- *Ball Bearings*
- *Cylindrical Roller Bearings*
- *Spherical Roller Bearings*
- *Tapered Roller Bearings (Tyson)*

* Reg. U. S. Pat. Off. Tyson Bearing Corporation

SKF INDUSTRIES, INC., PHILADELPHIA 32, PA.

Now is the time to put pushbutton power starting on small gasoline engines!

Act now to build powerful new sales features into your product

Only six months after our first announcement, large initial orders *prove* that the trend to the Fairbanks-Morse Pushbutton Starter is a fact! Even we were surprised at the fast response — with new emphasis and meaning we now repeat what we said in January: *"Muscles are going out of style for starting small gasoline engines!"*

A Fairbanks-Morse starter, operated by either a 12-volt battery or 110-volt a-c power, fits your rope-started engine just as it is. You simply substitute this powerful new sales feature for your present starters, right on the assembly line. At the same time, the addition of a power source opens the way for electric lights, controls, and other new design ideas and accessories that put your product ahead of the field in performance and sales.

FAIRBANKS-MORSE

A name worth remembering when you want the BEST

MAGNETOS • REWIND AND ELECTRIC STARTERS • WATER SYSTEMS • GENERATING SETS • PUMPS • MOTORS • SCALES • DIESEL LOCOMOTIVES AND ENGINES

The battery-operated model includes a charger that brings the battery up to full charge simply by being plugged into a 110-volt a-c outlet. The starter itself offers the exclusive design advantages and rugged long service of Fairbanks-Morse Rewind Starters, plus sure-fire pushbutton operation. If your product is powered by a small gasoline engine, and you want to make it more attractive to your dealers and users, send the *coupon* below for our new descriptive bulletin on *pushbutton power starting!*

WRITE TODAY for this concise illustrated bulletin offering cutaway photos, detailed drawings, specifications, and application chart — the facts you need to know about today's most important starting device for small gasoline engines.

FAIRBANKS, MORSE & CO.
MAGNETO DIVISION
BELOIT, WISCONSIN

Name_____

Company_____

Street_____

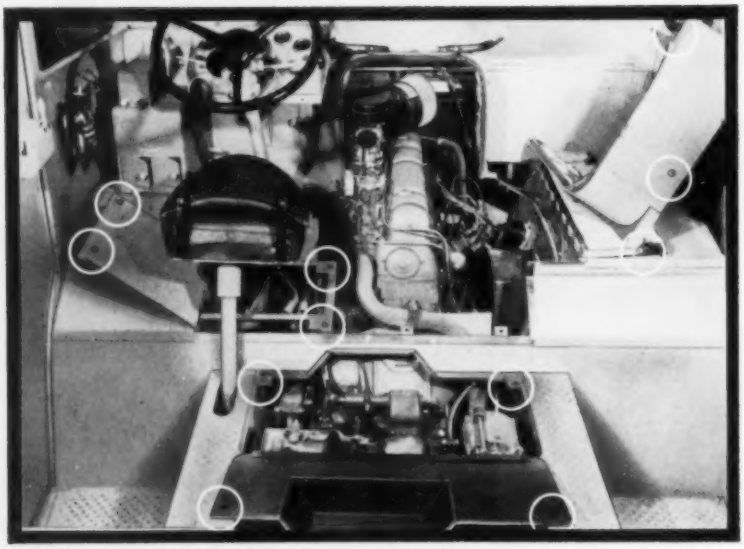
City_____ State_____

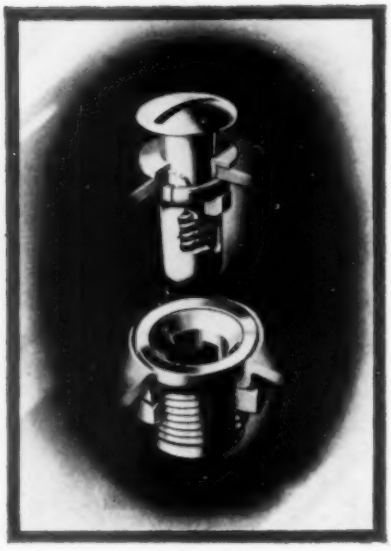
Design problem:

Fastening of removable panels

Your best answer:

Economical, easy-to-install QUICK-LOCK





Photograph courtesy Divco-Wayne Corporation, Detroit, Michigan

In Divco delivery trucks,

QUICK-LOCK guarantees

trouble-free opening and closing

of cowlings and access panels

Among the outstanding design features which have contributed to the success of Divco door-to-door delivery vehicles is the sure, quick closing and opening of cowlings and panels. To provide easy access to engine and transmission, Divco specifies Simmons QUICK-LOCK on demountable covers of various shapes and thicknesses.

QUICK-LOCK has unlimited applications in the electrical and electronic, automotive, appliance, aircraft, and other manufacturing fields. *Here's why* millions are in use today on many types of valuable equipment cases, weather-tight lighting units, voltage regulators, engine panels, and access panels and doors:

- A 90-deg. turn locks and unlocks QUICK-LOCK. No special tools needed.
- Stud is self-aligning; speeds up mounting and demounting of removable panels.
- When unlocked, stud is self-ejecting—easily checked by visual inspection.
- Various stud and receptacle types...oval, flush, and wing-head studs; easily installed plate and screw-type receptacles.
- Helical spring in stud supports initial load; solid stud part holds increased load.
- Design features allow for curved sheet installation, and even slight misalignment of holes.
- *Maximum economy in production* assured by single hole mounting of screw-type receptacle.

Send today for the Simmons Catalog

Where does QUICK-LOCK belong in your design? For complete information and specifications, write for the Simmons Catalog today. Samples and free engineering service are available upon request.

SIMMONS

FASTENER CORPORATION

1751 North Broadway, Albany 1, New York

QUICK-LOCK • SPRING-LOCK • ROTO-LOCK • LINK-LOCK • DUAL-LOCK

Guarantee TOP Performance and Maximum Life!

Specify THESE TOP QUALITY FEATURES...

(Standard on Miller Cylinders at no extra cost)

Specify CASE HARDENED CHROME PLATED PISTON RODS

On all Air and Hydraulic Cylinders

Benefits To You

CASE-HARDENED Piston Rods (52-54 Rockwell "C") provide practically complete protection against damage from hammer blows, wrench-dropping, mishandling, and similar occurrences. ***Available from Miller at no extra cost.***

The HARD CHROME PLATING over the case-hardened rods protects against scratch-damage and rust. ***Available from Miller at no extra cost.***

Specify "TEFLON" WIPERS

On all Air and Hydraulic Cylinders

Benefits To You

"TEFLON" Rod Wipers and "TEFLON" Hydraulic Piston Rod Seals withstand temperatures from—100°F. to plus 500°F. They are impervious to practically all known chemicals, including the fire-resistant, special, and standard hydraulic fluids in current use. ***Available from Miller at no extra cost.***

Specify TEFLON HYDRAULIC ROD SEALS

On all Hydraulic Cylinders

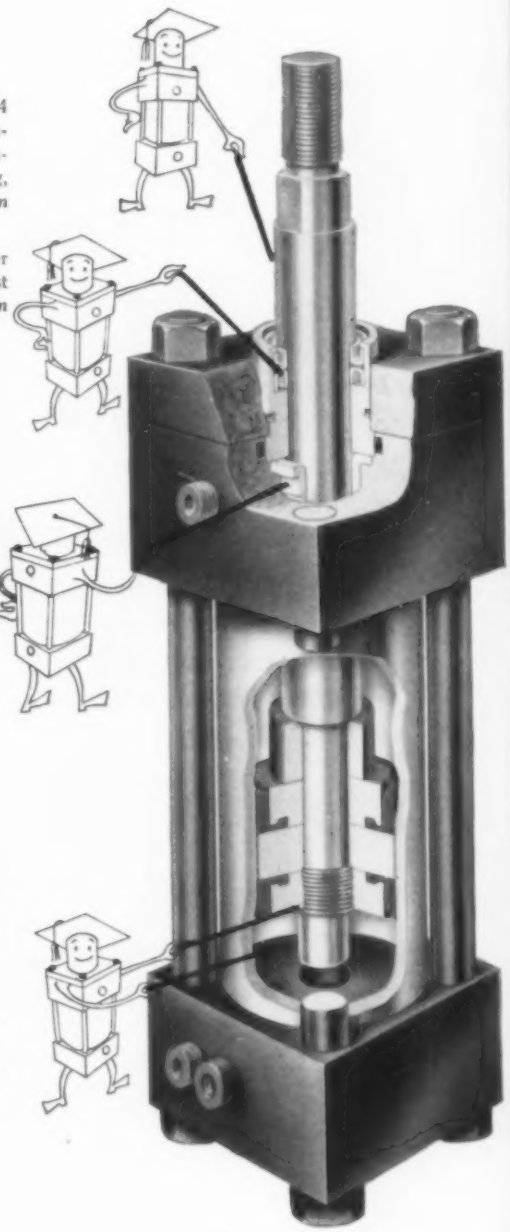
Specify RUST RESISTANT SURFACES

On all Air and Hydraulic Cylinders

Benefits To You

Highest quality Black Ferric Oxide Finish provides rust protection in air cylinder operation and on all cylinders during shipping and installation.

Cylinder heads, caps, mountings, pistons, followers, tie rods, and the unplated portions of the piston rods have this finish ***at no extra cost on all Miller cylinders.*** (This finish not recommended for water service)



You may wish to route this entire page to the proper department in your company, by using this handy form. Additional copies on request. →

To (Dept.) _____

"On all our future cylinder requirements, please specify the above quality features."

Signed _____

Title _____

NOTE. On all Miller Hydraulic Piston Seals: Leather Cup Seals are *standard*, Piston Ring Seals are optional *at no extra cost*, and "Teflon" Cup Seals are available *at extra cost*.

Member of the National Fluid Power Association

SALES AND SERVICE FROM COAST TO COAST

CLEVELAND • YOUNGSTOWN • DAYTON • TOLEDO • CINCINNATI • COLUMBUS
PITTSBURGH • PHILADELPHIA • BOSTON • HARTFORD • NEW YORK CITY
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FORT WAYNE • SOUTH BEND • INDIANAPOLIS • MILWAUKEE • LOUISVILLE
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MILLER FLUID POWER DIVISION FLICK-REEDY CORP.

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COUNTERBALANCE CYLINDERS

MICRO SWITCH Precision

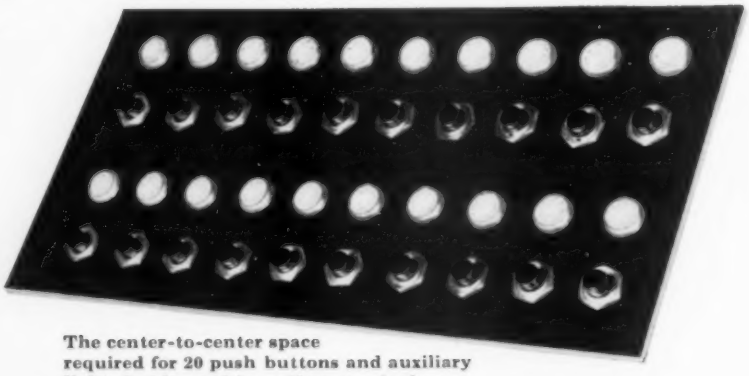
...FIRST IN PRECISION SWITCHING

Here is WHY you can

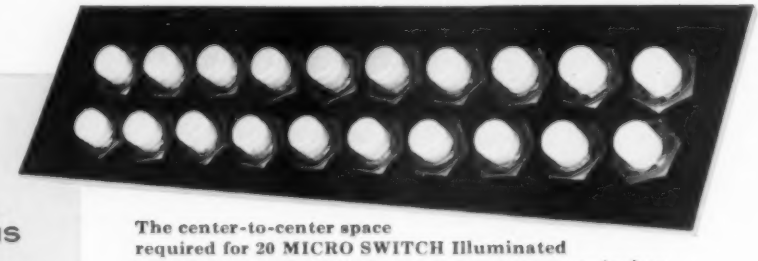
CUT PANEL SPACE **50%**

with MICRO SWITCH Illuminated Pushbutton Switches

Study this illustration... it shows how you can install a given number of MICRO SWITCH Pushbutton Switches—with illumination integral with the button in one-half the panel area necessary when push buttons requiring auxiliary on-and-off lights are used.



The center-to-center space required for 20 push buttons and auxiliary lights is 4 in. x 10 in.—40 square inches.



The center-to-center space required for 20 MICRO SWITCH Illuminated Pushbutton Switches is 2 in. x 10 in.—20 square inches.

FOUR SHAPES OF PUSHBUTTONS AVAILABLE IN FIVE DIFFERENT COLORS

These four translucent button styles are available for MICRO SWITCH Type 52 PB switches.

From the top they include (1) ¾ in. round; (2) ⅝ in. hexagonal; (3) ½ in. round; and (4) ¾ in. square.

They are available in red, yellow, green, blue and white.

(Send for Data Sheet #117)

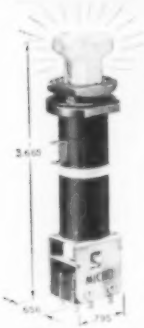
The savings in space, in time; the difference in operating ease and surety—all commend the use of MICRO SWITCH Illuminated Pushbutton Switches instead of combinations of switch and separate auxiliary on-and-off signal lights.

Here are four NEW MICRO SWITCH Illuminated Pushbutton Switches with many unique and specific features, detailed for you on the opposite page.

In addition to their other features, these switches are obtainable with any one of four different shaped buttons, in five different colors.

Read the specific details of each as set forth on the opposite page. If this information is insufficient for your purpose, ask for Data Sheets by numbers as shown on opposite page.

Switches have uses unlimited



NEW!

MICRO SWITCH Turn-to-Lock-Down Lighted Pushbutton Switch

This MICRO SWITCH lighted pushbutton switch is a dual-purpose switch. Pushed straight down, it functions as a conventional momentary pushbutton. A push and clockwise twist of the finger tip holds the switch in the operated position. A counter-clockwise twist returns the switch to the unoperated position. The low operating torque required permits the switch to be mounted flush or underflush on a panel without impairing ease of operation . . . This versatile switch can take the place of conventional push button, holding relays and separate indicator lights in many applications. Or it can take the place of an alternate-action pushbutton and provide optional momentary action.

#62PB7-T2

CHARACTERISTICS: Operating force 34 oz. max. Pretravel .220 in. min. Overtravel .120 in. max. Two subminiature switches are SPDT.

(Send for Data Sheet #116)

NEW!

MICRO SWITCH "Space Saver" Lighted Pushbutton Switch —only 2 in. max. below Panel

This MICRO SWITCH lighted pushbutton switch is invaluable in applications where space is at a premium. The switch has no pretravel spring mechanism which permits length to be reduced to 2.35 in. (less button). Only 2 in. max. required below mounting panel . . . This switch has a very definite snap-action "feel" and comparative high-force characteristics. Switch body contains a removable subminiature socket for the indicator lamp. Lamps are available for 6, 12 and 28 volts.

#62PB61-T2

CHARACTERISTICS: Operating force—32 oz. max. Pretravel—.070 in. max. Total travel—.110 in. max. Two subminiature switches are SPDT.

(Send for Data Sheet #123)

ELECTRICAL DATA

The subminiature basic switching units used in these four assemblies have SPDT contact arrangement. Contact break distance is .010 in. min. Underwriters' Laboratories list the switches at 5 amps. 125 vac. 30 vdc ratings are: Inductive 3 amps.—sea level, 2.5 amps. —50,000 ft. Maximum inrush rating: 15 amps. 125 or 250 vac and 30 vdc.

NEW!

MICRO SWITCH Magnetic Hold-in Lighted Pushbutton Provides Three Functions

MICRO SWITCH lighted pushbutton switch combines the functions of a three-pole double-throw pushbutton switch, indicating light, and holding relay into one compact unit which panel mounts on one-inch centers, both horizontally and vertically. Thus, the cost, wiring, maintenance and added space of these separate components are eliminated . . . A 28-volt dc solenoid is incorporated into the switch shaft. After the button is manually operated, the solenoid holds the switches in the operated position until electrically released. This feature gives the designer complete freedom in panel layout by eliminating the restrictions found in conventional mechanical release designs.

#53PB8-T2

CHARACTERISTICS: Operating force—35 oz. max. Pretravel—.050 in. approx. Total travel—.090 in. max. Three subminiature switches are SPDT.

(Send for Data Sheet #128)

NEW!

MICRO SWITCH Alternate Action Lighted Pushbutton Switch— for Multiple Circuit Control

#62PB61-T2

This MICRO SWITCH lighted pushbutton switch provides on-off control of up to four circuits. With each push of the button, both basic switches are alternated between actuated and unactuated maintained positions, thus providing double-pole double-throw action. Every two pushes of the button completes a cycle of operation. Variations in the long-life nylon index cam are possible which will permit a number of other sequences.

CHARACTERISTICS: Operating force—40 oz. max. Total travel—.100 in. max. Two subminiature switches are SPDT.

(Send for Data Sheet #124)

MICRO SWITCH

A DIVISION OF MINNEAPOLIS-HONEYWELL REGULATOR COMPANY

In Canada, Leaside, Toronto 17, Ontario • FREEPORT, ILLINOIS

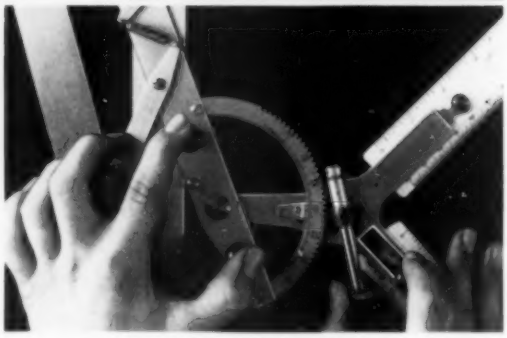
EMMERT means SPEED .... SPEED beats DEADLINES!

OPERATES EQUALLY WELL IN ANY POSITION

EMMERT MICRO-DRAFTER

Extensive, on-the-job, research in drafting departments has demonstrated that EMMERT Micro-Drafters add one extra hour of production to every eight hours worked . . . without speed-ups.

These highly versatile units may be mounted on any standard drawing board. Write for a demonstration today.



ACCURACY . . . with an EMMERT you can draw—absolutely parallel—horizontal and vertical lines the full length and width of the board with one continuous stroke . . . and—absolutely parallel—lines at any angle the length of the scales. . . . No other drafting instrument can match this precision.

SPEED . . . an EMMERT operates with finger-tip control, changing position to any area of the board, accurately in seconds. There are no blind spots.

DURABILITY . . . EMMERT'S stainless steel construction, absolute minimum of wear points and moving parts assures unlimited use and operation before requiring service.

MICROMATIC QUADRANT

Here, precision is accomplished by an amazingly simple design. Accuracy of all angles from 0° to 360° and adjustment to 2½ minutes is assured by fine precision tooling. Full visibility at all times and clear sharp calibrations eliminate eye-strain. The entire counter-balanced unit travels the full length of the vertical blade evenly and smoothly with just-rite pressure. Just a slight thumb pressure releases the worm gear permitting the desired amount of movement. Finer settings are made by the handy worm screw.

EMMERT builds many desk and board units to be used in conjunction with the Micro-Drafter

Address inquiries to Emmert Mfg. Co., Dept P, Waynesboro, Pa.

EMMERT

DRAWS THE ACCURATE LINE

EMMERT MANUFACTURING COMPANY

WAYNESBORO • PENNSYLVANIA

PERSPECTIVES

in design and development . . .

Who Looks After Uncle Sam?

Any industrial research and development program exists only to promote present and future marketable products. And, any interest that industry may have in military research and development is attributed directly to the advantage it may have in future government contracts. Still, the question is often asked, "Why conduct military research and development in service-operated laboratories? Industry can do the same job and do it better." The idea being too, that one can always buy defense, and that the government should not be engaged in anything that smacks of "government-in-business."

Monitoring The Field

Government laboratories are essential, particularly in those fields for which no civilian demand exists, such as ordnance components and missiles. But, it is the continuity of development in a field such as this which is perhaps that most important. This monitoring function which the government laboratories performs in ordnance is accomplished in the field of aeronautics, for example, by the competition between aircraft companies. Consequently, it is possible to know on a competitive basis how much a plane should cost and what is reasonably possible due to the normal advancement in the state of the art.

This is not true for missiles, nor ordnance equipment, for quite different factors are operating. Here it is difficult to establish the proper cost, or the performance to be expected of a missile, and without the help of the government laboratories in the field, it is difficult for the government to properly monitor its large investment in this field. Then there is the difficulty of getting a compromise between what is technically possible and what is needed from a tactical standpoint. Tied to this is a large increase in cost of the finished product over what would be possible if the extent of improvement was properly weighed against the technical difficulty of its achievement.

Technical and Tactical Compromise

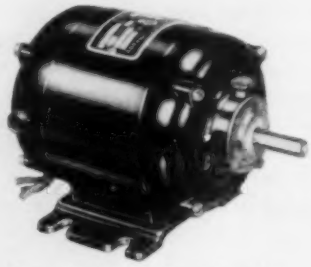
According to the director of research at one of the government's Arsenals, "Between the military services and their requirements and the company in industry that undertakes to fulfill these requirements, there must be a step which can be filled only by qualified career technical personnel in government laboratories who can translate these military requirements into scientific and engineering principles which are readily understood in industry. Also, many people overlook the fact that people in government laboratories are constantly studying battle conditions as well as general military service conditions."

Re-Education Is Expensive

Along this line, the Technical Director of a government Ordnance Laboratory added, "With an industrial product, everyone knows the conditions of operation. But industry is not trained to design for military environment. One of the greatest losses in military industrial operations today occurs in that period of transition from development to production, and in what amounts to a re-education of the industrial staffs of the producers. If we can find a better way of affecting this transition, we will have made a saving of many millions of dollars. Most organizations engaged in ordnance work have seen cases of waste, because the technical information developed by the originators of the design was not, or could not be,

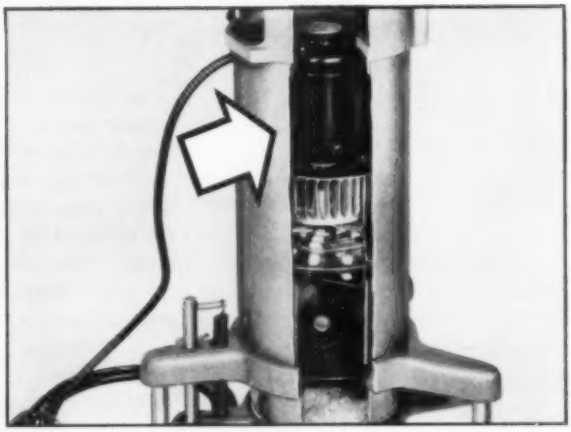
(Continued on page 131)

"They're rugged... stand up remarkably well" reasons Dietert moisture testing equipment uses BODINE MOTORS



Bodine Type NSE-13, universal motor

This 1/16 HP Bodine motor drives the fan in the Dietert Moisture Teller, an instrument designed to measure the amount of moisture in any material—solid, granular, liquid or semi-liquid. Dietert has found Bodine motors to be extremely rugged and the Bodine line to include the wide variety of fractional horsepower motors needed in the instrument field.



Here's a cutaway view of a Dietert Moisture Teller, showing a Bodine Type NSE-13 universal motor. Operating at speeds up to 5000 rpm, the fan forces volumes of air, controlled in temperature and velocity, past an electric heating element, and through the sample being tested. The sample which was weighed before testing, is reweighed after testing to determine moisture content.

Here's a Bodine-motor-powered Dietert Moisture Teller in action. The operator can determine the moisture content of a wide range of materials . . . for example, textiles, soaps, tobacco, foodstuffs, chemicals, and many other materials. Because the quality and value of many materials depend on moisture content, frequent tests are important.

Mr. D. L. Buss, President, tells why Harry W. Dietert Co., uses Bodine Motors:

"Our laboratory testing equipment is oftimes put to use in areas where it has to operate under difficult atmospheric conditions. Bodine Motors are rugged. Over the years they have stood up remarkably well. Then, too, in the Bodine line of motors we find the variety of fractional horsepower types required in the instrument field."

Be sure your motor is as good as your product. For information contact Bodine Electric Company, 2260 West Ohio St., Chicago 12, Ill.... or check your Sweet's Product Design File.

BODINE
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MOTORS
...the power behind the leading products

Bodine manufactures fractional horsepower electric motors for:

adding machines, letter openers, sanders, vending machines, exhaust fans, duplicating machines, hand dryers, portable tools, sound recorders, air conditioners, check protectors, respirators, voltage regulators, X-ray timers, traffic signal timers, stirrers, calculating machines, envelope sealers, and for many other applications.

passed on effectively to the production people sufficiently to assure a satisfactory production item. Since there is no industrial counterpart for ordnance fuzes, at least 50% of every defense dollar spent for ordnance work goes to the training and education of industry to keep up with this type of military production.

"The value of the dollar spent for ordnance research and development is two-fold. Even more valuable than the weapons which it produces is the ever-growing background and capability of the persons who engage continuously in weapons design. Europeans solved this problem with the establishment of munitions industries like Krupp, and Skoda. This could be done in this country, but only if the concept of a large munitions industry were acceptable to the American people."

Flexibility of Operation Cuts Costs

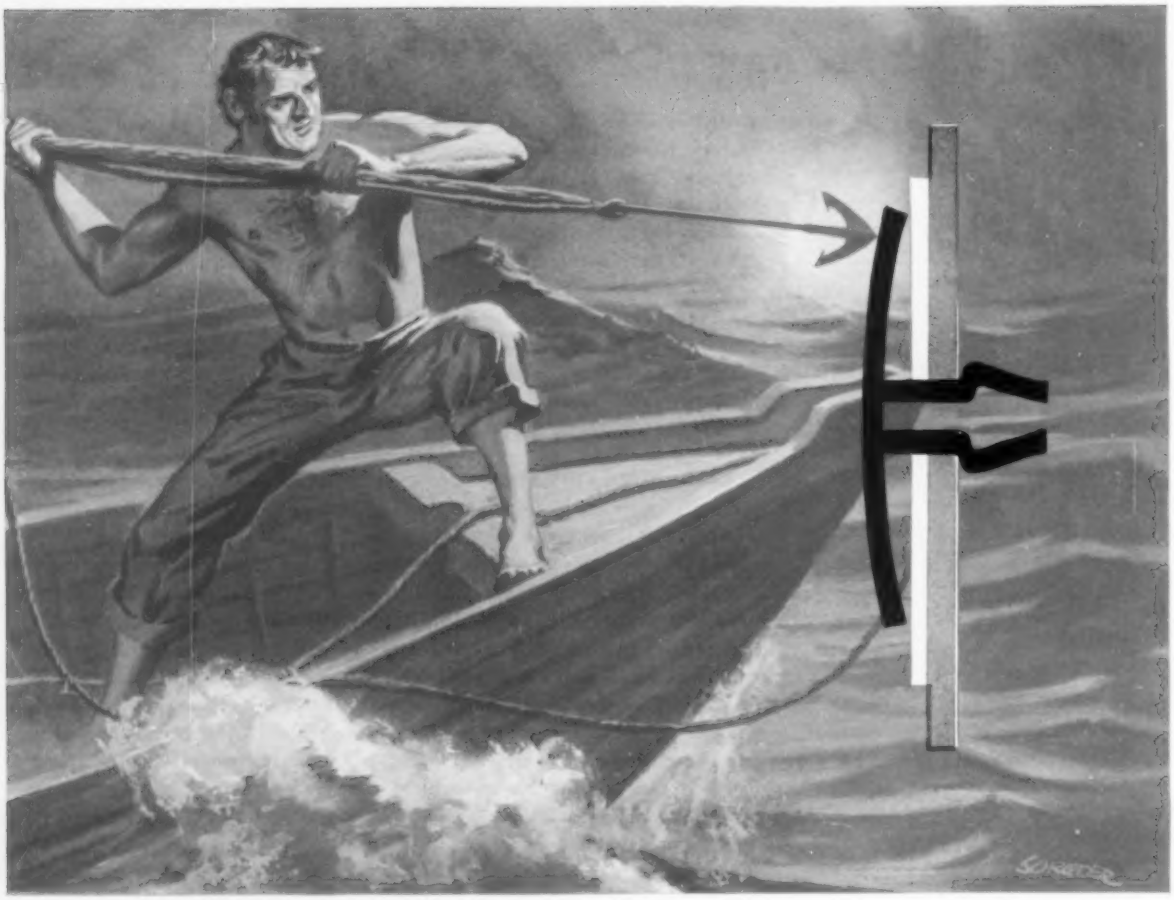
At the Naval Ordnance Test Station, China Lake, Calif., the modified industrial accounting system used keeps a close check on all of the costs. The Technical Director reported that on projects which have been conducted on the basis of a fixed specification, his group was able to carry out the completed development at a cost closely comparable to that of industrial organizations operating under the same ground rules. "Our real savings in cost come when we are given the opportunity to modify specifications in such a way as to achieve the best balance between tactical desirability, as shown up in our test work, and the fleet assistant projects, and, the technical feasibility which is represented by the research, design, and production engineering personnel. In the case that we have complete flexibility, we feel that we can achieve a weapon which will satisfy a given need adequately at perhaps 1/10th of the cost which would be required to meet a more detailed design specification. I believe that this was achieved in the Sidewinder missile."

One research director of a government laboratory said that an engineer in a laboratory such as his is in a position to get a broad view of industrial potential, as there are few industries or companies that do not freely entrust their company secrets to government laboratories. Therefore, the government laboratory engineer is in a position to select from this broad field all of the newly developed accessories, mechanisms, or materials, and apply them to military needs. "On the other hand," he added, "I have observed many times over industrial organization either through lack of knowledge or through company pride avoiding the use of an item which may be from a direct competitor. If the contractor is supervised by career professional people from a government laboratory, these situations can be avoided."

No Government Labs, No Quality Control

"If the government were to abolish its laboratories," according to the China Lake, Naval Ordnance Test Station Director, "I believe that the government would soon find itself in the same position an industrial organization would be if it were to abolish its quality control and inspection groups. Most of the pressures for the abolition of government laboratories come from those groups who would like to do research and development work on government funds without the necessity for accounting, on a technical basis, for their performance in the use of these funds."

And, from a former government laboratory employee and now research director of an electronics firm, comes the remark, "The fact that a laboratory is operated by a private concern or the government has nothing to do with it. It is how the lab is run and the results it get that count. No one is infallible. There are badly operated industry laboratories (check the list of corporations that failed); and there are poorly operated government laboratories—specifically some of the arsenals. With the latter, in almost all cases the major fault is bureaucracy." —PAUL ANDERSON



HARPOON-ACTION FASTENER
simplifies front mounting

Thrust this Tinnerman Dart-Type SPEED CLIP® through the front of a panel. Spring-steel fingers compress, then expand to lock tight, never to loosen until you pull the clip out.

This time-saving SPEED CLIP feature can be combined with other Tinnerman fastening principles and almost any spring-steel shape. Result—multi-purpose, cost-cutting fasteners that solve a variety of fastening problems. You eliminate screws, nuts, lockwashers, secondary fastening methods. You reduce parts handling and achieve a faster, smoother assembly-line flow.

Your Tinnerman representative can show you these and many other SPEED NUT® Brand Fasteners that can help take assembly costs out of your products. Call him today. Or write to . . .

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The Look of Things

HAND CRAFTSMEN, in the days of the guilds, were artists as well as technicians. They built beauty into their work with their own tools; time was incidental. With the rise of factory production, however, time became important and machine motions had less versatility than those of the hand. Many early products of the machine were ugly; they lacked new concepts of appearance design to replace the handcraft ones. They were imitations, in effect, as the early automobiles imitated carriages and the early railroad cars imitated wagons.

Reactionaries like John Ruskin fulminated against ugly products of the machine and advocated a return to pre-industrial society. Other men, like William Morris, organized societies to revive handcrafts. But Sir Henry Cole took the positive approach; he published a "Journal of Design" and tried to correct misuse of materials in machine production. Unfortunately, Victorian industrialists interpreted his suggestions as an argument for ornament, and the scrollwork and "gingerbread" surface design of the Victorian Age was the result.

Eventually, designers began to realize the need for aesthetic standards suited not to hand production, but specifically to the machine. The first emphasis was on logical structure or design simplicity. This culminated in the Bauhaus, a consulting art center for industry, founded in Germany in 1919 by Walter Gropius. He gathered about him "a picked body of men of all-around culture who were thoroughly experienced in the practical and mechanical, as well as the theoretical, scientific, and formal aspects of design."

The ideals and experience of the Bauhaus were the source of modern design. The first effect was "functionalism", but designers came to realize that pure functional design is not always beautiful. There have been later excursions into streamlining and other novelty ideas. These usually result because company management views the industrial designer as only a stylist, concerned primarily with decor, as in the automotive industry.

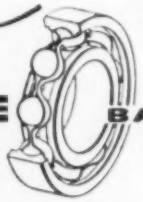
The true concept of industrial design goes far deeper. It must encompass consideration of consumer needs, production problems, design limitations, costs, and sales pressure. The industrial designer must balance function, mechanical design and costs against production conservatism, sales desire for novelty, and consumer resistance to the radical. Ford, for example, recognized the problem in appointing a vice-president in charge of design. Other companies recognize it also—more than 4000 industrial designers, employed or independent, are now at work in the United States.

Their challenge for tomorrow is to integrate functional requirements with our human need for beauty.

FACTS

about

NEW DEPARTURE BALL BEARINGS



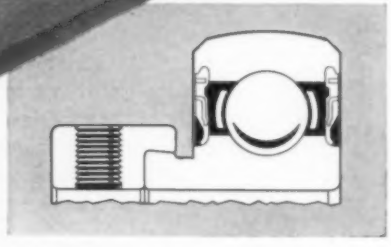
NOW A NEW DEPARTURE IN PILLOW BLOCKS

- Clean, rigid, compact design.
- Free of any lubricating fixtures.
- New Departure ball bearings sealed and lubricated-for-life.
- Pillow Blocks easily mounted without special tools.
- Only high capacity precision ball bearings used.
- Accommodates any misalignment.
- 31 shaft sizes, ½" through 2 7/16".
- Interchangeable with most makes.

Send for Catalog PBC for complete details.

GREASE SEALED IN
DIRT SEALED OUT
with
FAMOUS SENTRI-SEAL

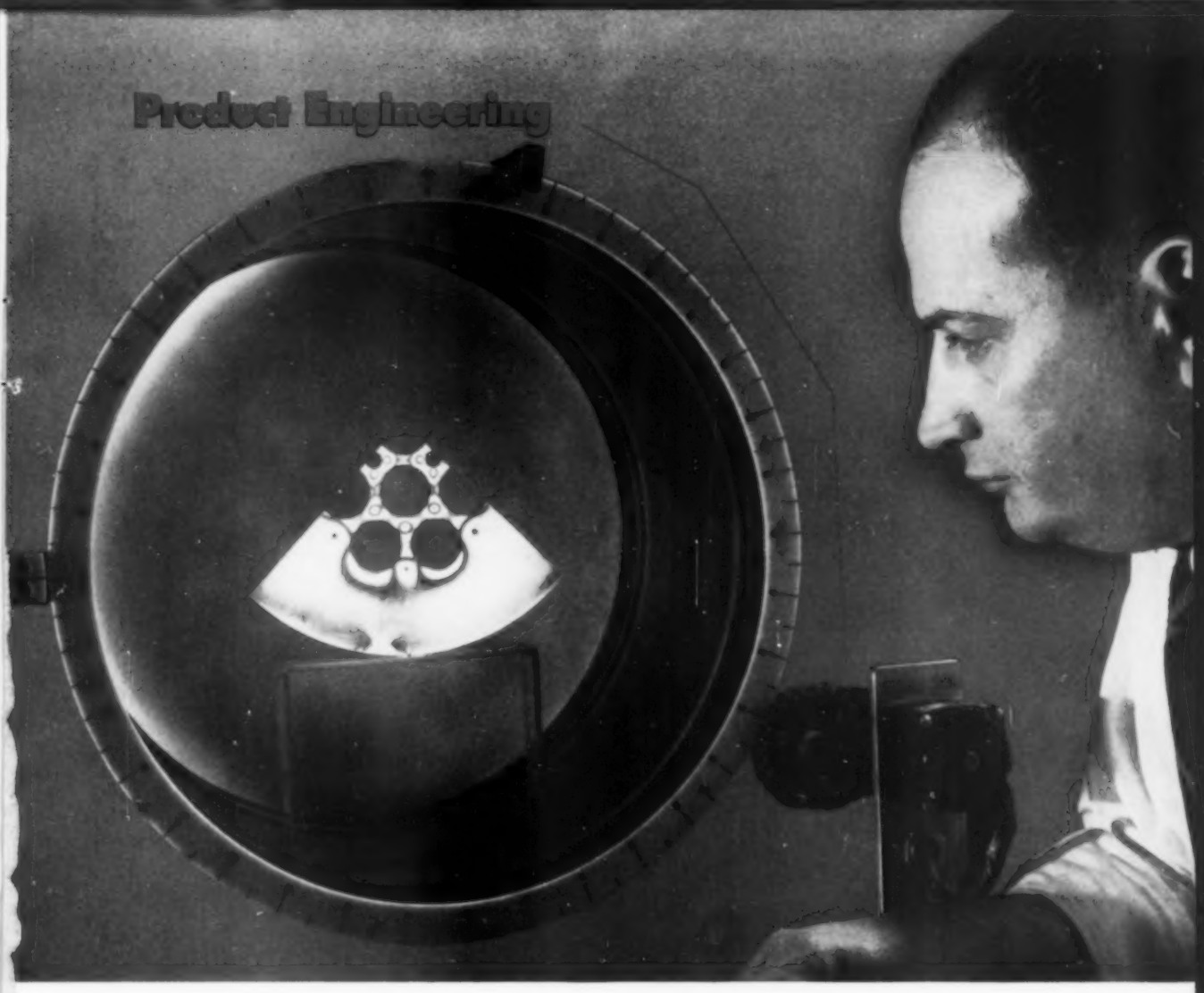
New Departure Pillow Blocks employ the performance-proved New Departure Type AE Adapter ball bearings with spherical O.D. for alignability and steel-reinforced Sentri-Seals for long life protection against dirt or grease leakage.



The bearings are easily applied to the shafting and are positively locked in position with an eccentric cam locking collar and set screw.

BALL BEARINGS MAKE GOOD PRODUCTS BETTER

NEW DEPARTURE • DIVISION OF GENERAL MOTORS • BRISTOL, CONN.



Epoxy Casting Resins Simplify—

Three-Dimensional Photoelasticity

M. M. LEVEN
Westinghouse Research Laboratory

An old technique gets a new start with easy-to-handle materials. Here is an up-to-date evaluation of the best model materials, simplest equipment and most effective methods for practical three-dimensional photoelastic stress analysis of complex structures and parts.

HIGHLY stressed parts of unusual shape or loading such as bolt threads, pressure vessels, shrink fits and turbine disks running at high speed often defy theoretical analysis. The "frozen stress" method of three-dimensional photoelastic analysis can determine precise stress distributions in all of these situatior and in many others.

In this method a plastic model is heated to a critical temperature, loaded, and then slowly cooled with the loads still acting. After cooling to room temperature the loads are removed but the strains remain fixed or

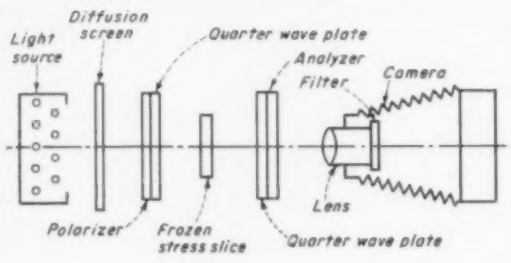


Fig. 1—Diffusion circular polariscope. Light source has two staggered rows of green and white fluorescent lamps. Flashed opal diffusion screen gives uniform light field. Polarizer and analyzer disks, as well as quarter wave plates, are in rotatable mount. Wave plates are removable for conversion to plane polariscope. Frozen stress slice can be coated with oil film to minimize surface irregularities. Camera lens with long focal length is in tandem with Wratten 77A, filter for light of correct wavelength. Camera is equipped with a long bellows extension.

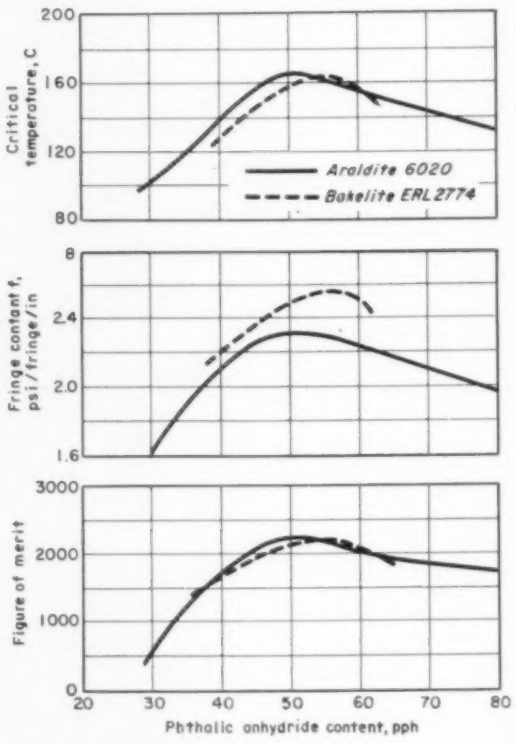


Fig. 2—Frozen stress properties of two epoxy casting resins. Although peak values occur at 50 and 55 parts per hundred by weight, other factors such as ease of casting, tensile strength and residual stresses require lower values of 45 and 50 pph, respectively, in practice.

locked in the model. These strains represent an elastic distribution of stress and careful cutting or slicing of the model will not disturb them.

Complete methods for three-dimensional photoelastic stress analysis have been developed, but the technique has not been widely used primarily because suitable materials were lacking, and the equipment and method appear complex.

Equipment Required

Aside from model machining and darkroom facilities and a suitable oven for model loading, only a simple diffusion circular polariscope is needed. The outstanding feature of such a polariscope, Fig. 1, is that it contains but one lens, the camera lens. It is simple to align and the light intensity is high enough that patterns are visible in a lighted room.

The light source can contain both green and white fluorescent lamps, so that the light can be changed from white to monochromatic. The opal glass diffusion screen can be obtained from any glass company. The polarizer and the analyzer, as well as the quarter wave plates, are relatively inexpensive and readily obtainable, Table I. The camera lens is the most expensive part of the apparatus. A long focal length increases poraliscope accuracy: A focal length of about 19 in. is recommended, although a focal length as short as 7.5 in. can be used. Polaroids and quarter wave plates should be in rotatable mounts with quarter wave plates easily removable.

Model Materials

A high Figure of Merit is the most important property a model material must possess for three-dimensional frozen stress tests. This is the ratio of elastic modulus and material fringe value, both measured at the critical temperature. The Figure of Merit is a relative measure of the number of fringes produced by a unit strain. A high value insures a detailed fringe pattern and model deformations in proportion to those in the metal prototype.

The best materials available for three-dimensional frozen stress tests are the acid-cured epoxy casting resins. Table II shows the Figure of Merit of some of the earlier plastics used for three-dimensional photoelasticity compared with a typical epoxy resin. Two epoxy formulations having high values are: (1) 100 parts by weight of Ciba Araldite No. 6020 and 45 parts by weight of phthalic anhydride, and (2) 100 parts by

TABLE I — EQUIPMENT SOURCES

Item	Source	
Polarizer, analyzer and quarter wave plates:	Pioneer Scientific Corp.	New York, N. Y.
	Polarizing Instruments Co.	Irvington-on-Hudson, N. Y.
	Polarized Light and Photoelastic Co.	Staten Island, N. Y.
	Polaroid Corp.	Cambridge, Mass.
Epoxy resins:		
Araldite No 6020	Ciba Co.	New York, N. Y
ERL No 2774	Bakelite Co.	New York, N. Y.
Both resins and pre-cast cylinders available from:	Houghton Laboratories, Inc.	Olean, N. Y.
Phthalic anhydride hardener:	Monsanto Chemical Co.	Cleveland, Ohio
	American Cyanamid Co.	Bridgeville, Pa.
	Houghton Laboratories, Inc.	Olean, N. Y.
Mold releases:		
DC 20	Dow Corning Corp.	Cleveland, Ohio
Hysol M670	Houghton Laboratories, Inc.	Olean, N. Y.

weight of Bakelite ERL 2774 and 50 parts by weight of phthalic anhydride. Frozen stress properties of these epoxies vary with hardener content as shown in Fig. 2.

In addition to having a high Figure of Merit, these epoxies meet all of the other requirements of a good photoelastic material and can be readily cast in large sizes. Epoxy parts can be cemented together to simulate welded structures or to facilitate model making, with no disturbance in the fringe pattern at the joint.

Epoxy resin coatings also show great promise of being suitable for measuring the surface strains on metal parts both in the elastic and plastic range by the "Photostress" technique. Here an epoxy coating in strip or coating form is placed directly on the polished metal surface or on a reflecting undercoat. When polarized light is passed through the coating and reflected, the photoelastic effect measures the strains on the surface of the metal part caused by the applied loads.

Casting Cycle

Because residual stresses must be held to a minimum in photoelastic models, casting procedure is much more critical than for casting epoxy parts in production. The main difference is the precise control of heating and cooling rates required to produce stress-free castings.

The entire mixing, curing, and annealing cycle for an epoxy casting cured with phthalic anhydride appears in Fig. 3. The temperature rise rate α_r and the drop rate α_d depend upon the size of the casting and are given conservatively, in deg C per hr, by the following equations, where D is the casting diameter, in inches. For hollow castings, twice the wall thickness may be substituted for the diameter.

$$\alpha_r = \frac{25}{(50 + D^2)}$$

$$\alpha_d = \frac{-25}{(25 + D^2)}$$

The rate of temperature rise thus calculated will be slow enough to produce a gradual polymerization and the temperature drop slow enough to prevent the "freezing" of any thermal stresses into the casting.

Epoxy resins are simple to cast compared to previously used photoelastic materials such as the polyesters; however, castings of limited size can be purchased, Table I.

Interpreting the Model

Selection of slices is the most critical phase in any three-dimensional photoelastic investigation, and requires careful planning before models are made or tests run. Slices should be chosen so that the desired information can be obtained using light at normal incidence to the slice in the simple diffusion polariscope. This means that slices should be made along known principal planes such as planes of symmetry or free surfaces. While simplification can be obtained in slicing if specialized techniques such as the oblique incidence method are used, considerable error can result and the savings in time is seldom justified.

The results of careful slice choice are illustrated by

Fig. 3—Mixing and curing cycle for phthalic anhydride-cured epoxy resin. Stirring and additional heating is required to bring mixture back to 115 C, solution temperature for 45-50 parts of anhydride. Gellation temperature must not fall below 95 C or anhydride will precipitate. One to three days will gel mixture to a rubbery solid for oven curing, where a long cure is essential.

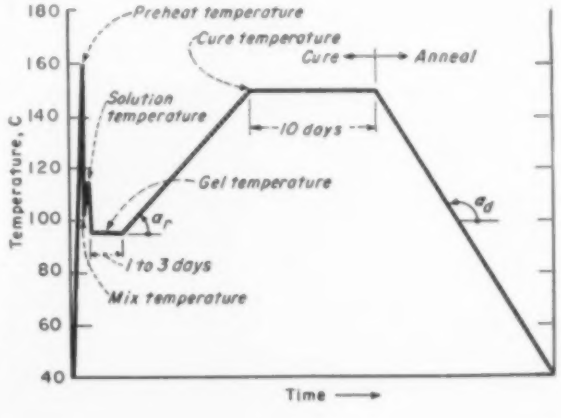


Fig. 4—Frozen stress analysis of 6 inch diameter welded pressure vessel. (A) Slice orientation: Meridian stresses σ_m determined by meridian slice; hoop stresses by transverse slices in cylindrical portion, by surface slices in torospherical head and fillets of flat head. Arrows show direction of polarized light. (B) Stress pattern in $\frac{1}{4}$ in. thick meridian slice: Numbers are fringe orders which, when multiplied by fringe constant f/t (8.52 here) yield meridian stresses on outer surface. On the inner surface, these stresses are reduced by the pressure. (C) Distribution of dimensionless stresses σ/p on inner and outer surfaces: Both meridional and circumferential stresses agree closely with strain gage tests on steel vessel.

the analysis, Fig. 4, of a cylindrical pressure vessel with a toroidal top and a flat bottom. Because of the rotational symmetry of the vessel and loading system, a meridian slice is a plane of symmetry or a principal plane. The stress pattern for this slice (B) thus yields the meridian stress σ_m on the inner and outer surfaces. The circumferential or hoop stresses have the same direction as the incident light and therefore have no influence on the stress pattern. Final distribution of meridional stresses on the outer surface, as shown at (C), compared closely with strain gage analysis, showing the validity and usefulness of the frozen stress method.

Circumferential stresses σ_θ are determined over the cylindrical portion of the vessel by using transverse slices with normal incidence. On the toroidal and filleted portion of the vessel, surface slices are used as shown in (A). The fringe order determination using normal incidence on the surface slices becomes a point-by-point procedure along the curvature of the slice. Dimensionless hoop stresses for inner and outer surfaces are shown at (C) by dashed lines.

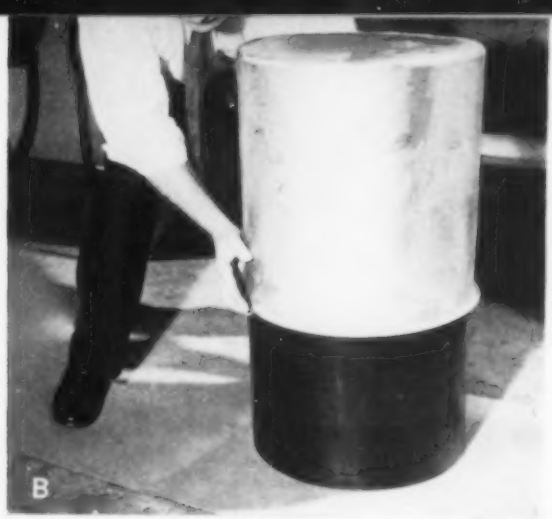
Determination of fractional fringe orders is another important factor. There are usually less fringes in three-dimensional photoelastic tests than in two-dimensional cases. This is especially true for surface slices which must be thin so the average stress in the slice will approximate the surface stress. The **Tardy method** of compensation is the most practical method of fractional fringe order determination, because of its simplicity, accuracy, and the fact that no additional equipment is required.

For any Tardy analysis, polarizer and analyzer must be crossed and must coincide with principal stress directions at the point where fractional fringe count is desired. The method is most easily applied to boundary points where stress directions are known, such as at the hole in the circular shaft shown in Fig. 5. By rotating the analyzer, the integral fringe N nearest the edge (here, number 2) is moved closer to the edge. Rotation to an angle ϕ_b moves the fringe N just tangent to the edge. With a further rotation to a total

(Continued on page 140)

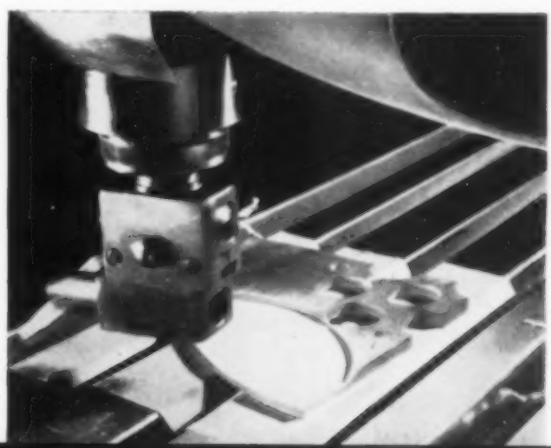
Table II—Frozen Stress Properties of Plastics

Material	Critical Temperature, deg C	Elastic Modulus E, psi	Fringe Constant f, psi/fringe/in	Figure of Merit, E/f
Bakelite 61–893	120	1,200	3.30	365
Trolen	80	1,250	3.00	415
Castolite	120	4,060	8.88	490
Fosterite	90	1,950	3.25	600
Kriston	135	12,000	6.25	1925
Araldite 6020	165	5,150	2.30	2235



3-D Analysis of Reactor Vessel

Steps in construction and analysis of model nuclear reactor pressure vessel. (A) Flakes of phthalic anhydride hardener are mixed into preheated epoxy base resin in aluminum container coated with silicone release agent; Cured cylinder (See Fig. 3) is removed from mold (B) and machined (C) using carbide tools, high cutting speeds and low feeds. At (D) machined plugs are cemented into drilled head with room temperature-setting epoxy. Assembled vessel (E) is placed in oven and loaded with nitrogen pressure (F). After several hours at load, model vessel is cooled and various parts sliced on band saw for analysis. Test slice from vessel head (G) is finished to desired thickness by fly-cutting. Note double masking tape for securing slice. Final stress pattern in head is shown in diffusion polariscope, first page.



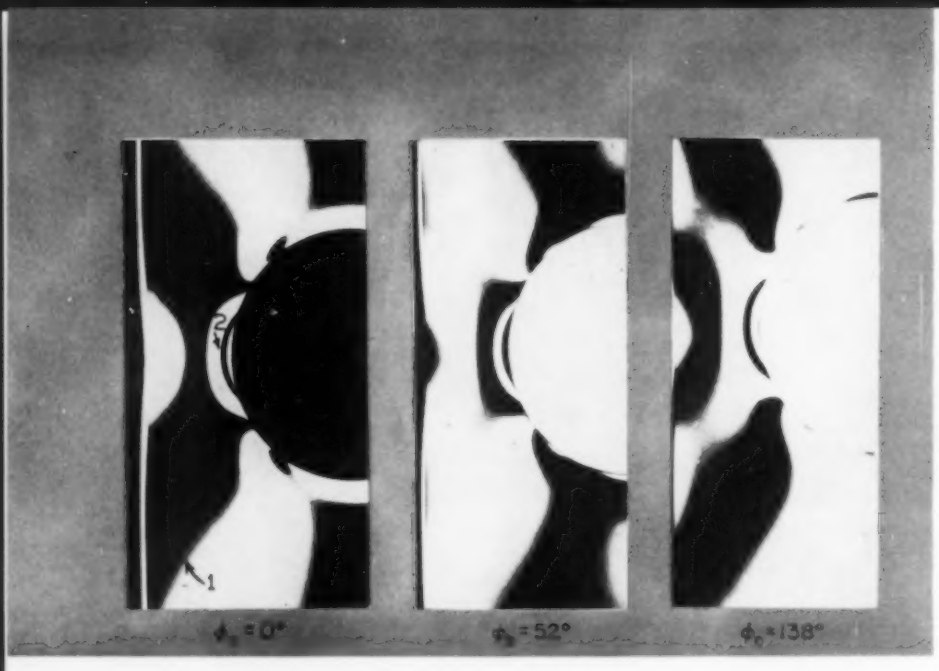


Fig. 5—Slice of circular shaft under pure tension with transverse hole illustrates Tardy "In-Out" method for fractional fringe orders. At (A), fringe number 2 is integral fringe nearest hole edge. Rotating analyzer brings fringe just to edge (B), then just past edge (C). Fringe order at hole edge is 2.53.

angle ϕ_c the fringe moves across the boundary and just barely vanishes. The fractional fringe order at the boundary is then:

$$n = N + (\phi_b + \phi_c)/360$$

This technique is called the Tardy "In-Out" method, and can be applied to interior points as well. Fringe orders can be measured rapidly by this procedure with an error less than ±9 deg in analyzer angle, which corresponds to ±1/20 of a fringe.

Interior stresses are more difficult to determine as compared to the stresses on free surfaces where the stress system is biaxial; however, interior stresses are seldom of great significance in practical design problems. Photoelastic methods have been developed for the general case of triaxial stress at interior points. But these methods are extremely cumbersome and require excessive skill for accurate results.

The "effective" stress, however, is a useful interior stress and may easily be determined by frozen stress methods. Based on the distortion-energy theory of failure, the effective stress may be calculated from

$$2\,\sigma_e^2 = (\sigma_1 - \sigma_2)^2 + (\sigma_2 - \sigma_3)^2 + (\sigma_3 - \sigma_1)^2$$

where $\sigma_1 > \sigma_2 > \sigma_3$ are the principal stresses.

Photoelastically, the effective stress is found by cutting a small cube from the frozen stress model at point desired, but with any orientation of faces. If the fringe orders n_x, n_y and n_z are measured for the three mutually perpendicular directions of light incidence, the effective stress equation becomes

$$2\,\sigma_e^2 = \left(\frac{f}{t}\right)^2 (n_x^2 + n_y^2 + n_z^2)$$

where f is the model material fringe value and t is the cube thickness.

The effective stress has found wide acceptance as a criterion for plastic yielding or fatigue failure and as such may have much more significance than the separate principal stresses.

Application

By cementing together several machined sub-parts, complex assemblies can be made of epoxy casting resins and analyzed by frozen stress techniques. An example is a complete model nuclear reactor pressure vessel recently studied at Westinghouse (see page 139). Shown are six steps in its construction and analysis.

The vessel, at (E), was made in three parts machined from solid castings, with the remaining cores used to make the caps, nozzles, studs and other small parts. The three parts were then cemented together using a room-temperature curing resin made of 100 parts by weight of Araldite 6020 and 8-12 parts of Araldite hardener HN 951. After rapidly stirring the hardener into the resin, the mixture is quickly applied because it gels in 10-30 min.

Machining of complex models can sometimes be simplified by coring. Cores should be flexible enough to accommodate resin shrinkage; one good method is to wrap layers of corrugated paper around a solid center, and coat the paper with the resin mixture in the previous paragraph.

Such careful construction and analysis gave the fringe pattern of reactor pressure vessel head stresses shown on the first page, one of several analyses. Note the symmetry of the pattern and lack of fringe distortion.

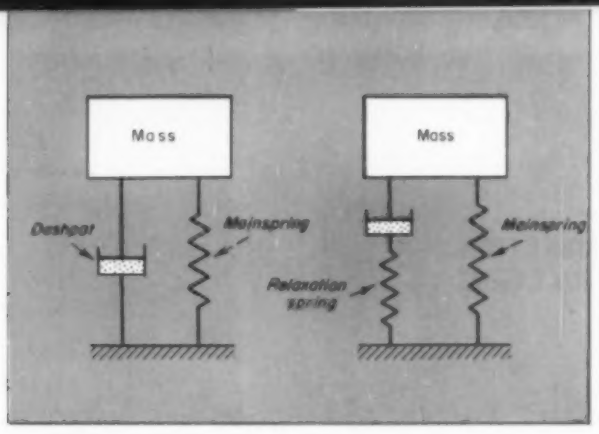
EDITOR'S NOTE: For more detail on some of the subjects covered here consult the following recent articles:

"Epoxy Resin Castings," June 1957 page 135. Additional information on base resins, hardeners, mold releases, mold materials, coring and casting design.

"Photostress," September 1956 page 167. A new photoelastic technique for observing and measuring surface strains on actual structures and parts. Also included is a section on optical principles for photoelasticity.

"Predicting Elastic Failures," March 1956 page 178. Five requirements for a practical theory for elastic failure; graphical methods for distortion-energy and maximum normal stress theories.

"Experimental Stress Analysis," January 1955 page 182. Criteria for determining which of the many available techniques to employ.



When a spring is used as a vibration isolator and damped with a dashpot in parallel (left) the conventional analysis accurately predicts force transmitted, deflection and damping loss. But when the elastic element is rubber or some other visco-elastic material with internal damping the conventional analysis may be in substantial error. For such a visco-elastic material, representation (right) with a spring added in series with the dashpot more precisely simulates the behavior of the isolator. The same method of analysis applied to an isolator using a mechanical spring in series with the dashpot can lead to better performance than obtained from a conventional system.

how to predict performance of rubber

VIBRATION ISOLATORS

WALTER W. SOROKA
Professor of Engineering Design
University of California

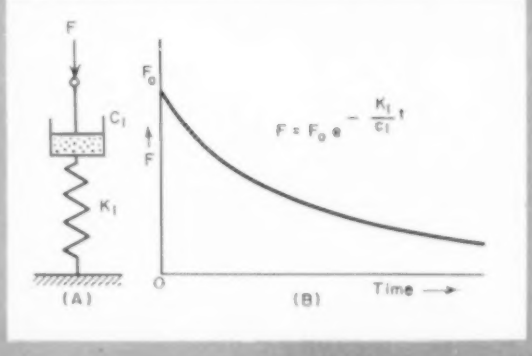
New method of analysis accounts for creep of visco-elastic materials such as rubber, nylon, rayon, and fibrous materials; can lead to designs with lower transmissibility and better performance under shock.

When visco-elastic materials such as rubber, nylon, rayon and rubber-like polymers are compressed suddenly they deflect elastically. If the deflection is held constant, however, the material creeps and the load required to maintain the deflection falls off or relaxes.

This creep behavior can be simulated by a relaxation unit consisting of a dashpot in series with a spring (A). If the upper end of this unit is suddenly pushed down a distance x_o by an initial force F_o and the deflection is held constant, the spring gradually works its way back to a no-load state, as shown in (B). The force F at any instant is $F_o e^q$ where q is $-k_1 t/c_1$.

When force, instead of deflection, is held constant a steady creep occurs after the initial deflection. Upon sudden removal of this force the creep will stop and the spring will recover its no-load position at once. There will be no creep recovery, however, and the dashpot plunger will remain in a displaced position.

By paralleling the relaxation unit with another spring, creep will occur under a constant load. As the added spring now supports the load, creep rate in this case diminishes with time. When the load is removed there is immediate elastic recovery followed by gradual creep recovery.



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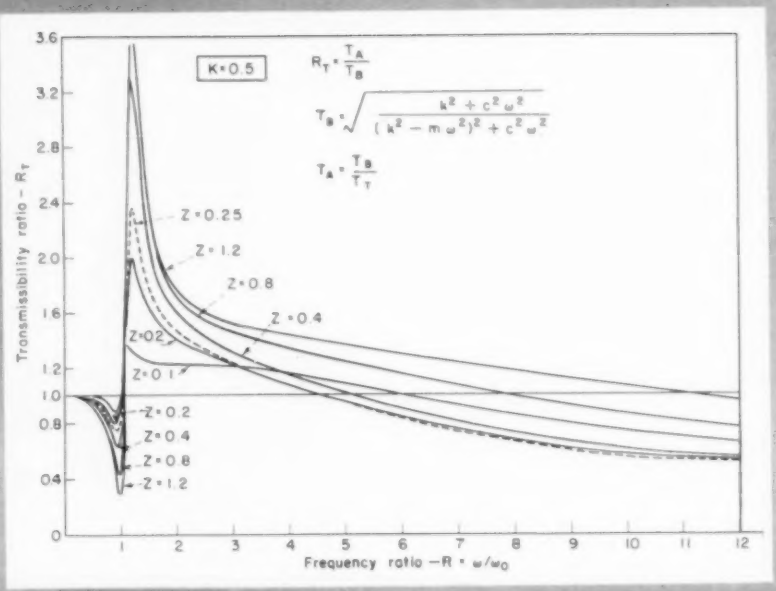
VIBRATION ISOLATORS . . .



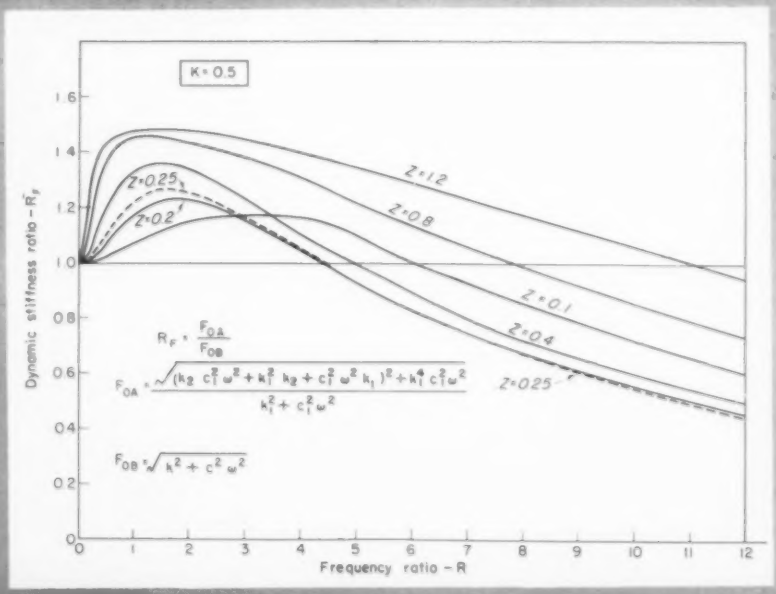
THREE FACTORS MEASURE

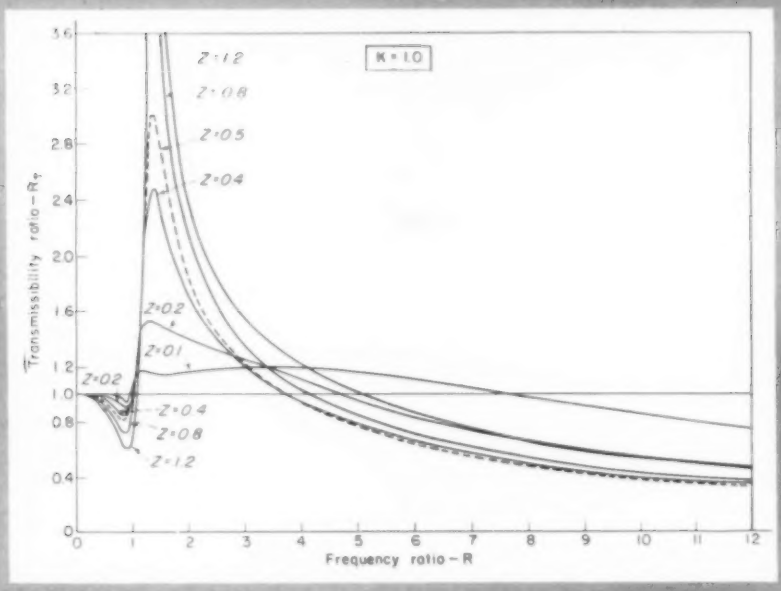
Performance of a vibration isolation system is measured by three factors: transmissibility (ratio of imposed force to transmitted force), dynamic stiffness (deflection rate at a given frequency), and damping (energy loss per cycle). The advantage gained by using a relaxation unit instead of a dashpot alone is shown in the three pairs of curves herewith, which plot the ratio of transmissibility, dynamic stiffness and damping loss with and without a relaxation unit.

Assuming harmonic motion, all three of these ratios —transmissibility, dynamic stiffness, and damping— can be evaluated against frequency ratio (imposed frequency divided by the natural frequency of the system). The dynamic effect of damping in these sys-

DYNAMIC STIFFNESS

Because damping varies with velocity the effect of a dashpot is negligible at low frequencies, more so in conventional systems than creep-simulating suspensions. In this set of curves, the ratio first increases with frequency, then drops well below unity. Dashed lines (maximum energy loss per cycle) give minimum dynamic stiffness ratios at frequency ratios greater than 5. In conventional suspensions the greater dynamic stiffness at higher frequencies increases transmissibility, and shock loads are not so well isolated.





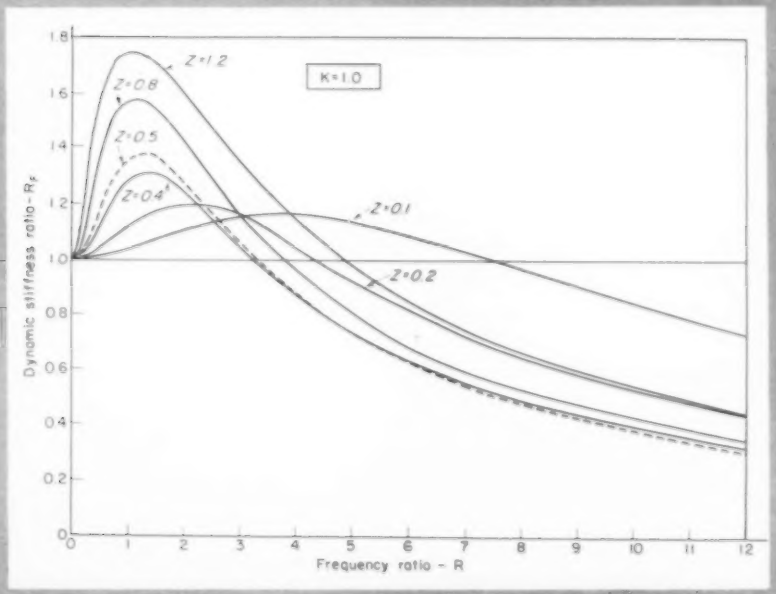
TRANSMISSIBILITY

Addition of a relaxation unit gives considerable improvement at usual operating speeds, where the imposed frequency is greater than 5 times the natural frequency of the suspension. Also, with increasing values of the damping factor there is an improvement at frequencies below resonance where the frequency ratio is less than 1.

DYNAMIC BEHAVIOR

tems can be indicated by a factor **Z** which is the product of viscosity of the damping material and natural frequency of the system divided by twice the stiffness of the relaxation spring. In each of the three sets of curves that follow, performance for frequency ratios up to 12 is shown by families of curves in which the damping factor ranges from 0.1 to 1.2.

Ratio of stiffness of relaxation spring to stiffness of main spring **K** also affects the dynamic response. Two values of stiffness ratio, 0.5 and 1.0, have been used in calculating a pair of curves for transmissibility, dynamic stiffness, and dynamic loss. In the transmissibility curves the dashed line shows the conditions for highest loss at resonance.



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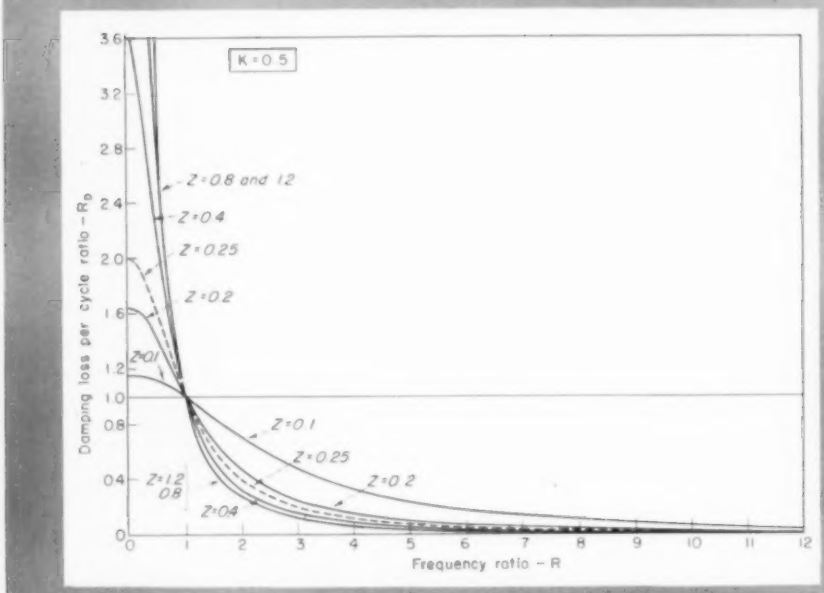
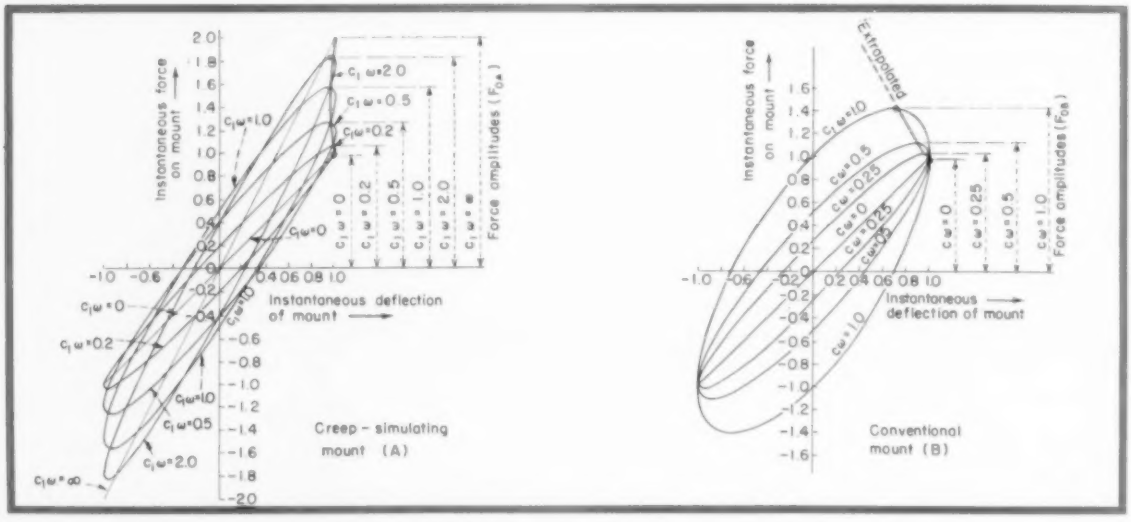
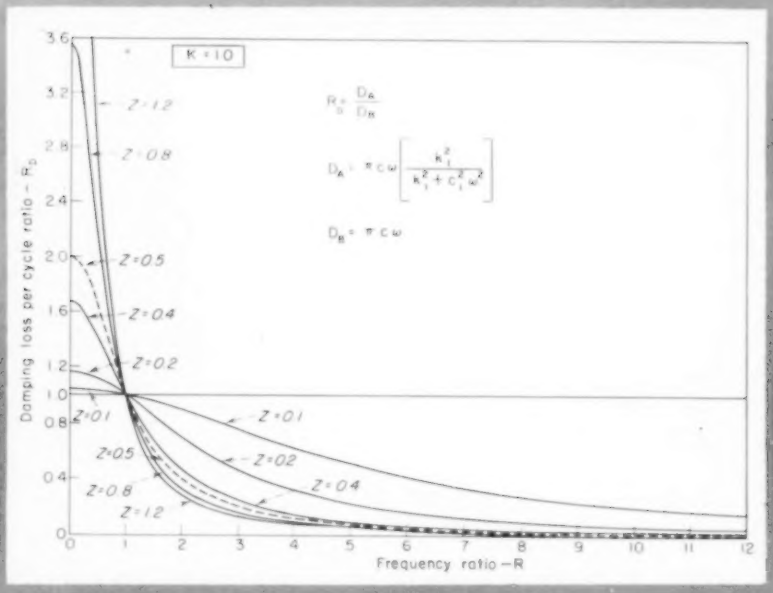
VIBRATION ISOLATORS . . .





Creep simulating suspensions never become "solid" at infinite frequencies. Even if the dashpot were replaced by a solid bar, the mass would still be isolated from the force by the two springs. Thus, the instantaneous deflection remains almost constant for any value of force. The colored lines in both sets of curves indicate how deflection varies with force for the various frequencies. Note that the hysteresis loop in this set of curves starts with zero area at zero frequency, increases to a maximum as frequency goes up, and then gradually goes back to zero as the frequency becomes infinite. Since shock-type loads are characterized by high frequency components, creep simulating suspensions would obviously be softer under such dynamic conditions than conventional suspensions.

Conventionally damped suspensions designed for normal operating frequencies are useless against shock, or rapidly applied loads. Viscous damping, increasing as it does with velocity, becomes virtually solid at high frequencies. This set of curves shows force-deflection history for a conventional suspension. For a constant value of c, as the frequency increases the suspension gets stiffer and F_{oA} increases. At infinite frequency the transmitted force, in theory, becomes infinite. In other words, the suspension would behave just like a solid mass subjected to a shock load. Except for the inherent elasticity of material the resultant reaction would be infinitely high. The instantaneous deflection of the spring mount would, of course, be zero.



DAMPING LOSS

At frequencies below resonance, damping loss is much higher in creep-simulating than conventional suspensions. At higher frequencies damping is less. This is desirable since damping will be more consistent throughout a wide frequency range. Behavior and results for creep-simulating suspensions are important when considering visco-elastic mounts such as rubber-like compounds and other plastic pads. Behavior of these mounts does not, in practice, agree with the conventional textbook treatment of viscously damped mounts.

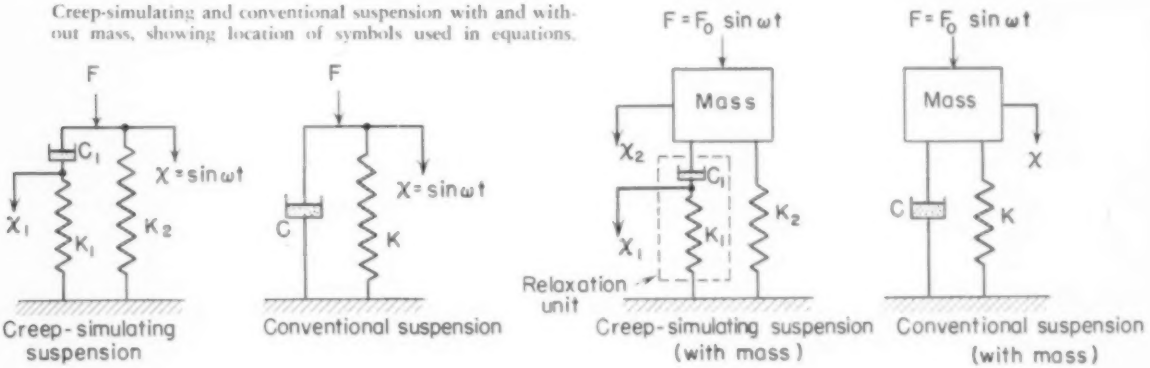
EDITOR'S NOTE: Recent articles by Professor Soroka dealing with vibration: "Vibration Isolated Equipment," December 1955 page 162, deals with the behavior of equipment capable of rocking motion in two degrees of freedom; "Shock Isolation," June 1955 page 167, discusses further the effect of shock loads on conventional suspensions; "Calculating Fundamental Frequencies of Machines," April 1954 page 190, explains methods to be followed for machines mounted on flexible supports; "Equivalent Dynamical Systems for Complex Vibration Problems," July 1952 page 130, gives the procedure for transforming complex structures into dynamically equivalent single-string lumped-mass systems with linear connecting springs for impact and vibration analysis.

Articles by other authors: "Selecting Vibration Isolators," September 1955 page 184, illustrations of available types of machinery isolators; "Simplified Analysis of Complex Vibration Problems," November 1953 page 161, is an approach based on the Mobility Method but with added advantages; "Shock or Vibration Isolators," June 1953 page 212, discusses the selection of proper mounts.

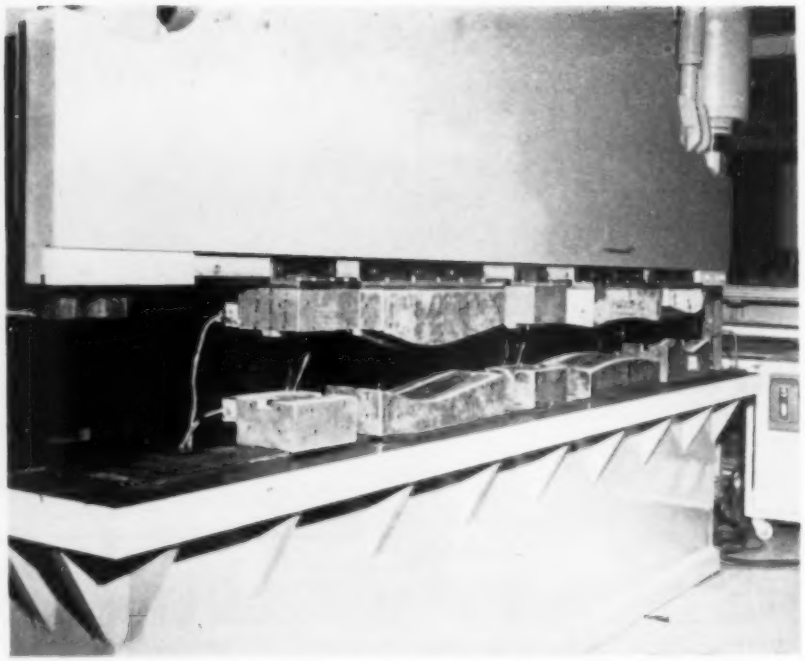
SYMBOLS

D_A	= damping per cycle, mount (A), lb/in./sec
D_B	= damping per cycle, mount (B), lb/in./sec
F	= force, lb
F_0	= initial value of F, lb
F_{OA}	= dynamic stiffness, mount (A), lb/in./sec
F_{OB}	= dynamic stiffness, mount (B), lb/in./sec
K	= stiffness parameter, nondimensional
R	= frequency ratio, ω/ω_O
T_A	= transmissibility, mount (A), lb
T_B	= transmissibility, mount (B), lb
Z	= damping parameter, nondimensional
c, c_1	= damping factors, lb/in./sec
e	= 2.7182
k_1	= Maxwell-unit spring stiffness, lb per unit displacement
k, k_2	= mainspring stiffness, lb per unit displacement
m	= mass, lb/in./sec^2
t	= time, sec
x	= unit displacement, in.
x_O	= maximum displacement, in.
x_1	= displacement at junction of c_1 and k_1, in.
x_2	= displacement of mass in mount (A), in.
ω	= frequency (sinusoidal) of displacement, rad./sec
ω_O	= resonant frequency, rad./sec

Creep-simulating and conventional suspension with and without mass, showing location of symbols used in equations.



Chance Vought separates final forming from stress relief for many parts, increases production five-fold by . . .



Finish hot-forming technique applied to standard hydraulic press brake to produce several different parts at once. Pieces requiring force from two directions must be made on hot-forming machine, as are parts with contours deeper than 30% of chordal length.

Hot Finish-Forming Ti

New technique based on electrically heated dies yields finished parts with zero springback in ½ to 3 minutes. Titanium shapes are classified into three groups, with formability chart showing when stress relief is needed.

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Production Department
Chance Vought Aircraft

THE properties that make titanium so useful in design are the principal ones that make fabrication so difficult: High strength and low ductility result in poor formability, while high strength and low elastic modulus give poor resistance to buckling and distortion during forming. These distortions are so large that hand-working titanium into the desired final shape becomes prohibitively expensive. Thus formed titanium parts often require stress relieving to control the final shape.

There are two other reasons why titanium parts require stress relief: (1) To remove residual stress resulting from such operations as brake forming, contouring and joggling. These stresses, in combination with assembly or operational stresses, can often produce delayed cracks particularly on the inside surface of bends. (2) Compression yield strength drops after stretch forming (Bauschinger Effect, Fig. 1). Thus, a part that is critical in compression, and is to be stretched in fabrication, requires stress relief.

A common quality-control requirement on titanium is to stress relieve for 1 hr at 950 F all parts formed beyond 1% elongation on rubber and stretch presses. Using this procedure with finish-forming dies has four basic drawbacks: (1) Fixtures are extremely large and mechanical handling is required, (2) Large fixtures reduce the number of parts per oven load and increase cycle time to several hours, (3) Heat losses in cooling massive fixtures are high, and (4) Rework rate on fixtures is high because titanium parts must be clamped under high loads at room temperature.

A new method for hot-forming titanium parts has been developed at Chance Vought to minimize these difficulties. Here, stress relieving has been separated

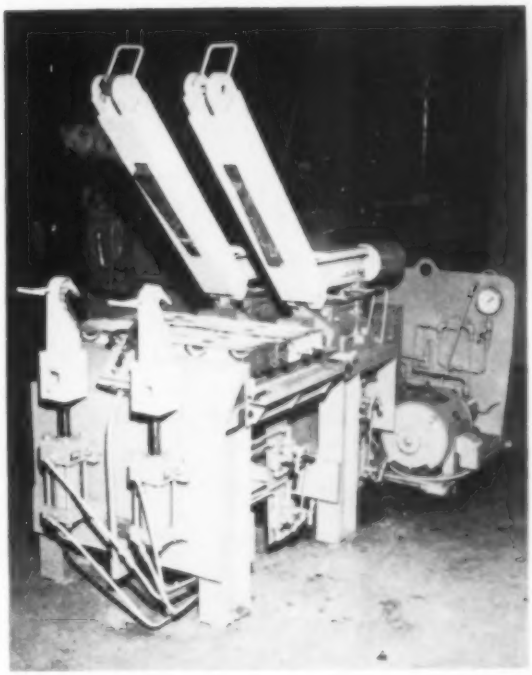


Fig. 2—Finish hot forming press for titanium parts. Insulated and electrically heated dies sit on heated platen 28 x 19 in. Forming pressure is applied in two directions by pairs of hydraulic cylinders. Finished parts are formed in ½-3 minutes.

from forming. It has been found that although the part must be stress relieved for 1 hr at 950 F, this time and temperature need not be maintained for final forming. With special tooling and equipment, titanium parts may be finish formed in a few minutes, instead of 4 hrs of stress relief with the part held in a fixture. In this way, a serious manufacturing bottleneck has been eliminated, and production of formed titanium parts increased about five times.

The new technique uses electrically heated dies insulated with marinite. Forming loads are applied in a special hot-forming machine, Fig. 2, or a standard press brake, (left), depending upon the number of restraints needed. In either type of press, several different dies can be accommodated at once. The titanium blank is held in the continuously heated die at 950 F only long enough to remove enough residual stresses for zero springback upon removal. A typical cycle is: 2 min dwell time before clamping, 3 min dwell time after clamping, and 1 min for reloading, for a complete cycle of 6 minutes. Many parts can be formed in shorter cycles.

Based on this finish hot-forming technique, titanium parts can be classified into three basic groups, Fig. 3, depending upon the severity of forming required: Forming limits for titanium are determined by the elongation ratio h/R and the buckling ratio h/t, where h is the section height, R is the contour radius, and t is the material thickness. These forming parameters are plotted in Fig. 4 and establish the boundaries of formability for each group:

Group I—Single-stage Forming from Flat Blank. Parts in this group can be finish formed in a male-female type die at 950 F in ½-3 min from a flat blank as illustrated in Fig. 3. The h/R and h/t ratios

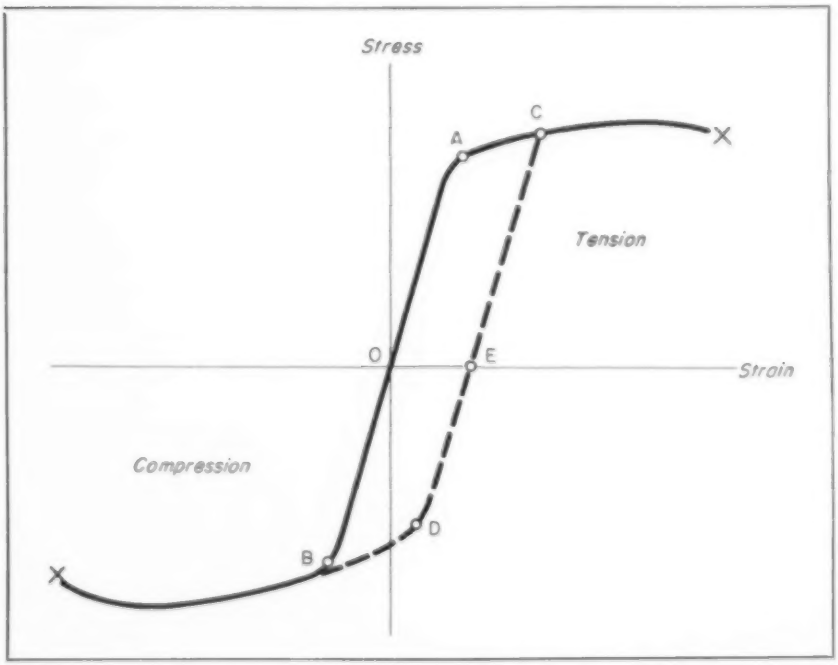


Fig. 1—Bauschinger effect for titanium. Stretch forming to C during fabrication reduces compression yield from B to D. Parts to be used in compression therefore require stress relief.

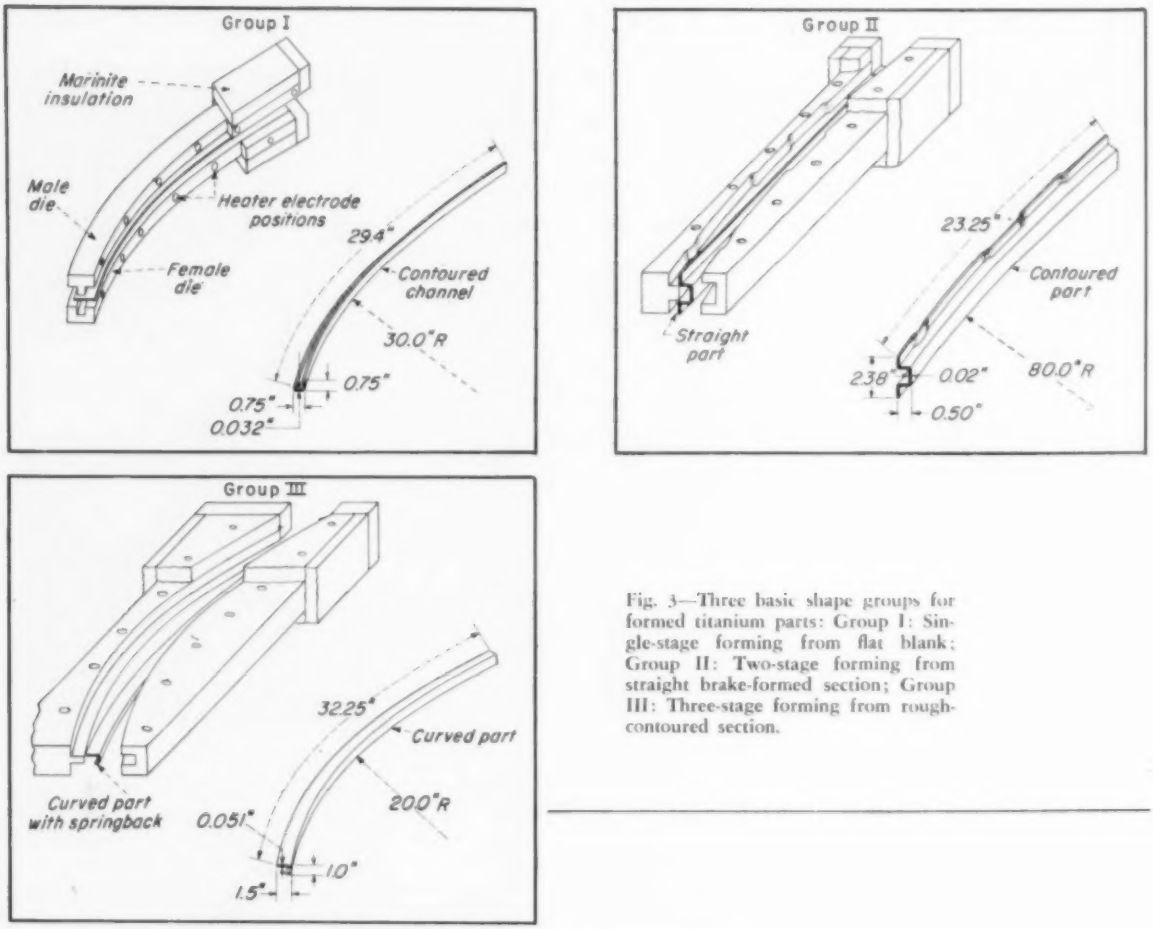


Fig. 3—Three basic shape groups for formed titanium parts: Group I: Single-stage forming from flat blank; Group II: Two-stage forming from straight brake-formed section; Group III: Three-stage forming from rough-contoured section.

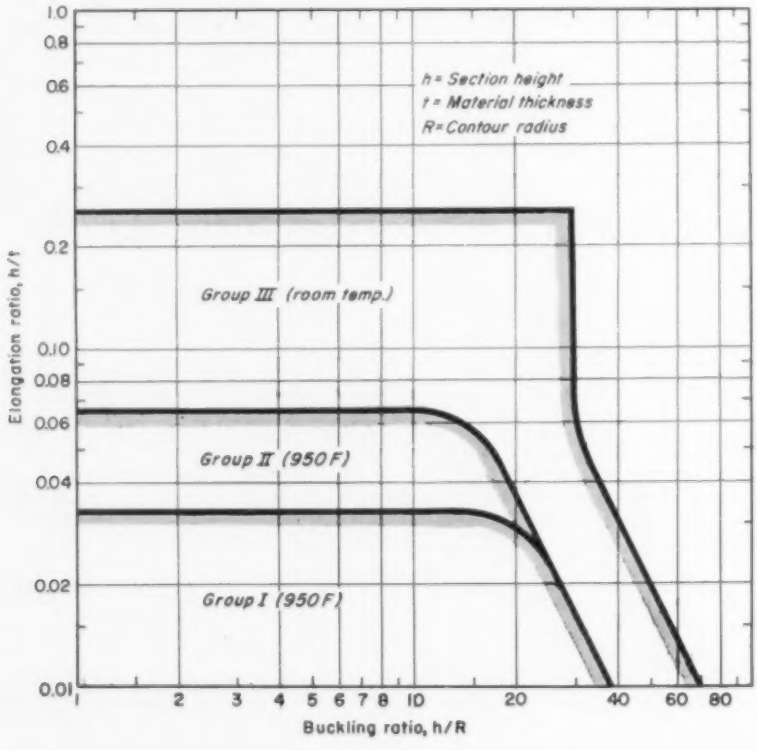


Fig. 4—Formability diagram for 4908 titanium showing limits for three basic part groups. Boundary for Group III parts is based on room-temperature properties because they undergo preliminary stretch forming before finish hot forming.

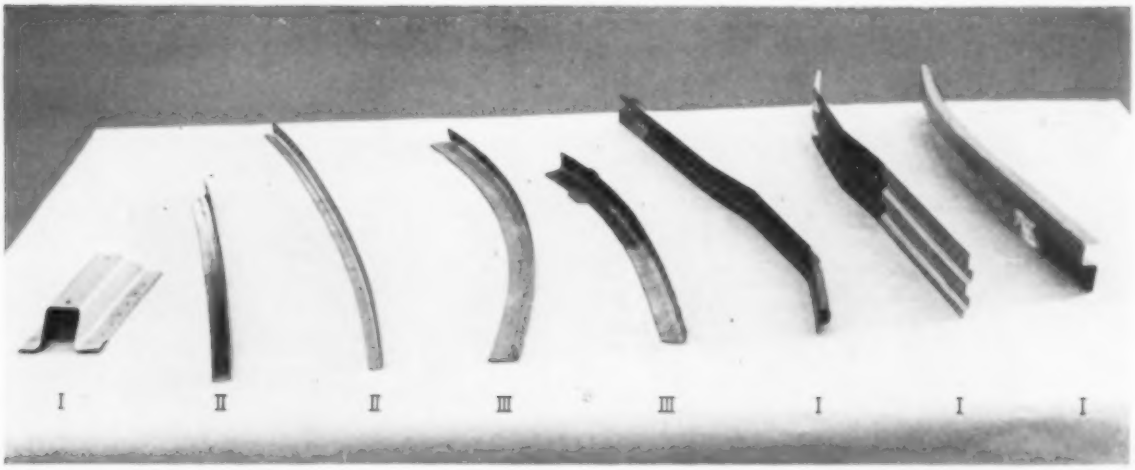


Fig. 5—Typical finish hot-formed titanium parts from each basic category. Group III parts are the only ones which require one-hour stress relief, because preliminary forming is done at room temperature.

must lie in the appropriate shaded portion of the formability diagram, or wrinkles will be produced that cannot be pressed out with the die.

Group II—Two-stage Forming from Straight Section. This group is classed as two-stage forming because the parts are initially brake formed to a straight section, then contoured in the heated dies for a few minutes as shown in Fig. 3. See Fig. 4 for the limiting curve of elongation and buckling ratios.

Group III—Three-stage Forming from Curved Section. Here, parts are brake formed and rough contoured on the stretch press before final hot shaping in Fig. 3. This group represents the only parts which require the one-hour stress-relieving operation, because it is the only one in which room temperature stretch forming is required. Consequently, the formability curve for Group III is based on room-temperature buckling data.

At present, Chance Vought makes about 2200 formed titanium parts, Fig. 5, for its F8U-1 production and its commitments to other aircraft manufacturers. Approximately 80% were being stress relieved, primarily for the production of a correctly shaped part, thereby eliminating hand working. Of this 80%, only about 30% of the total actually required stress relieving from a structural standpoint. Thus, 50% were being stress relieved for an hour just to obtain the desired shape.

With the finish hot-forming technique, all of the last category can be shaped in a matter of minutes as soon as re-tooling is complete. Part of the 30% are also to be made by hot forming because the time above 900 F is sufficient to produce simultaneous stress relief. With one medium-sized and one large-sized hot forming press, plus a hydraulic press brake, production of titanium parts is expected to increase 4½ times the rate achieved in the stress-relieving oven.

Finish hot forming results in substantial savings in four areas: (1) reduction of stretch-forming, drop-hammer, and stress-relieving operations, (2) material savings because of shorter blanks, (3) less rework on fixtures, and (4) less power requirements. Because hot finish-forming is such an efficient means of controlling springback in a production manner, the new process should have considerable impact on the forming of all high-strength materials.

Fig. 6—Entire titanium aft section of Chance Vought F8U-1 *Crusader* is being retooled for new method.

EDITOR'S NOTE: Other recent articles on titanium include:

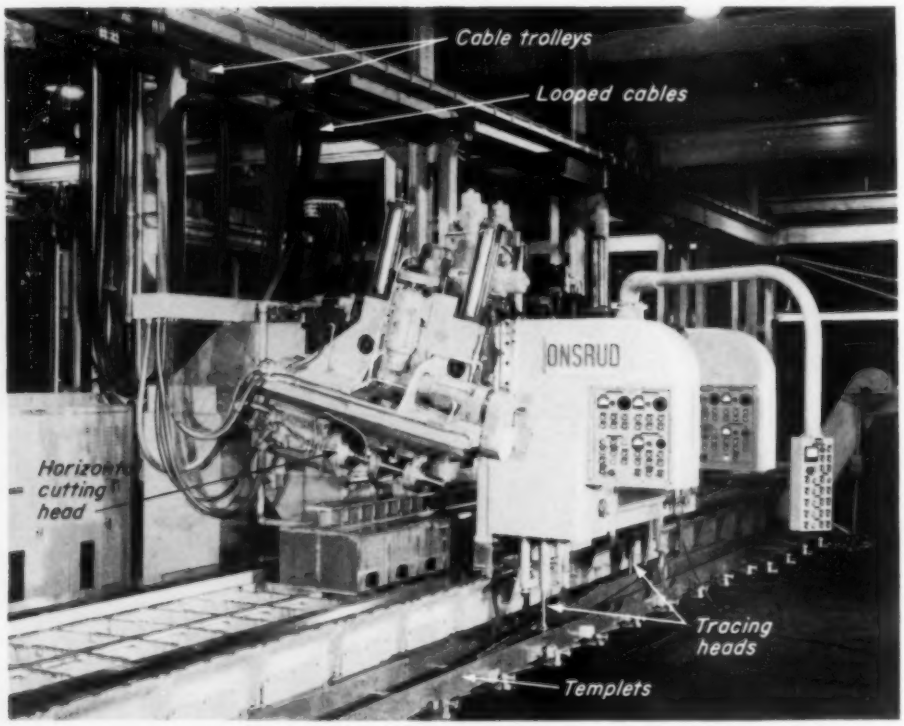
"Corrosion Resistance of Titanium" June 1956, page 187, presents data showing resistance to galvanic, marine and chemical attack; comparison with stainless and aluminum for wide range of chemicals.

"Forming Titanium Sheet" February 1956 page 135, discusses modifications in aluminum forming methods required because of differences in elongation, elastic limit, springback and buckling characteristics.

"Weldability of Titanium Alloys" Mid-October 1956, page D2, describes five basic evaluation tests for titanium alloys which simulate service conditions; tensile test, bend test, residual weld test, mechanical residual stress test, and strain aging test.

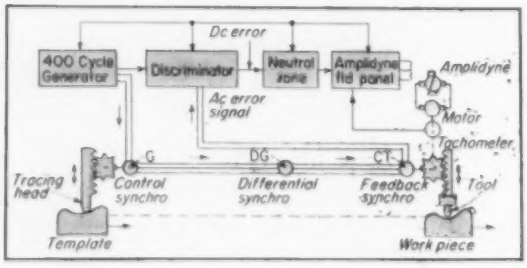
"Titanium Bolt Strength" April 1955 page 129, summarizes Navy program to evaluate titanium fasteners. Tensile, shear and endurance properties are compared with steel, stainless and aluminum bolts of the same dimensions.

"Titanium Forgings" December 1954 page 129, discusses how to design forged titanium parts.



Electronic Tracing Systems

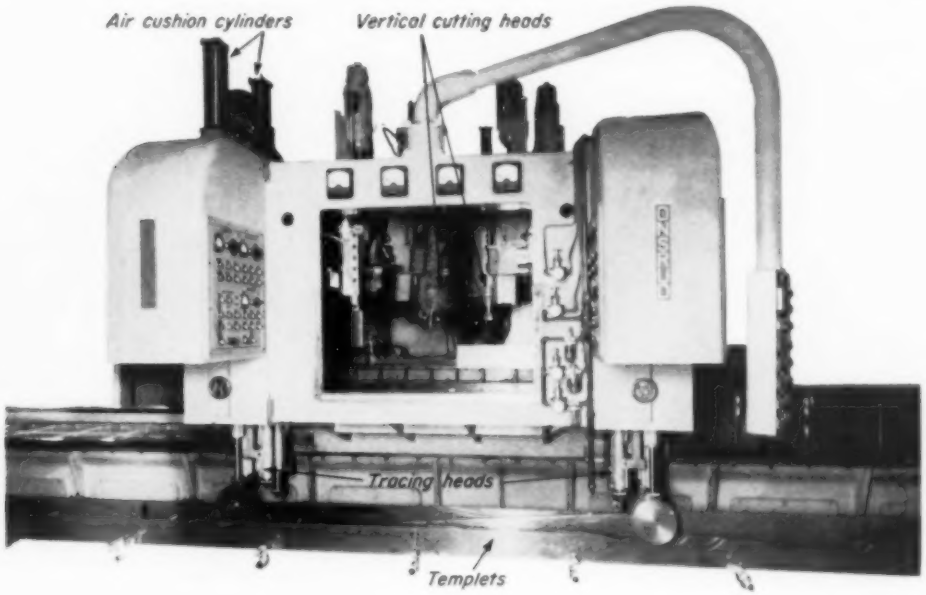
Removing metal at high speeds to make aircraft structural parts with relatively intricate contours has become a major production problem with the advent of high performance supersonic aircraft. Two recent machine tool developments, which meet this challenge, are a universal spar milling machine built by Onsrud Machine Works for the Air Materiel Command and a skin milling machine developed jointly by Cincinnati Milling Machine Co. and North American Aviation. Both machines use gantry-type carriages, electronic tracing systems, linear programming cams and large diameter peripheral cutters. Differences in performance and construction are related to their specialized applications.



ONSRUD MACHINE HAS FOUR CUTTING HEADS mounted on a box-like gantry carriage which slides on replaceable ways. Each cutting head has three controlled motions: a vertical traverse, a horizontal cross traverse and a rotation about an axis parallel to the bed. Two spindles are horizontal and two are vertical to obtain required variety of cuts. Horizontal heads carry 16 in. dia cutters with replaceable carbide tips. Cuts have been made in aluminum with repeat accuracies of 0.002 in. at carriage feed rates over 300 rpm and head feeds of 30 ipm. Machine is 84 ft long with a working space approximately 3 ft by 60 ft. Cast iron bed is made of three 18-ft and two 15-ft sections bolted together and can be lengthened by adding additional sections.

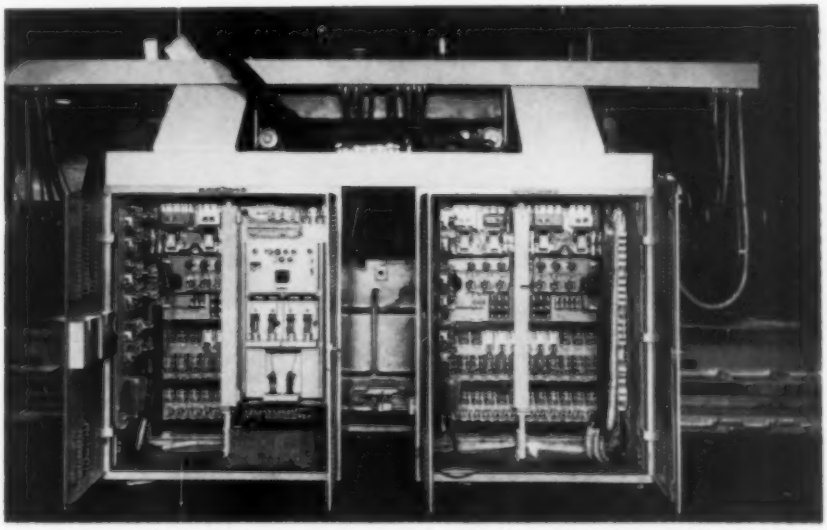
Each spindle motion is controlled by an independent one-dimension synchro servo system (left) from a separate templet. Templets which control cut contours are linear cams mounted on a rack alongside the bed. Tracing heads are ball bearing screw-and-nut units with the synchro driven by the screw. Heads can tilt 20° from vertical in either direction. A differential synchro is used as a manual positioning control.

IN NEW PRODUCTS



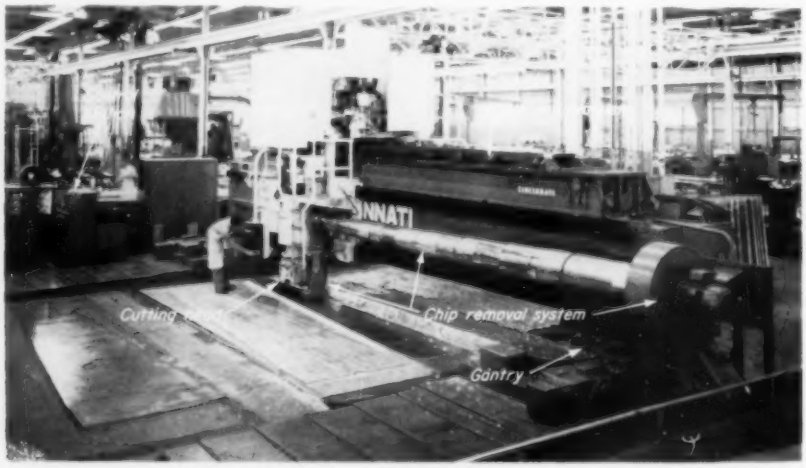
CARRIAGE is driven by an independent adjustable-speed drive which moves it along ways at speeds from 0 to 340 ipm. Motor drives a pinion which engages a rack on upper edge of bed on side opposite templets. Ball bearing lead screws are used to traverse all four cutting heads while a worm and gear sector tilt them into angular positions. To reduce loads on vertical traverse drives, part of cutting head weight is supported by air cushions. Control stations are adjacent to each cutting head on overhanging panels. A pendant station is provided also for convenience of operator.

Control Milling Machines



CONTROL CABINETS ON CARRIAGE house only those components directly related to machine's operating functions. This arrangement reduces both the weight of carriage and amount of interconnecting overhead cables between carriage and stationary cabinets. Cables are hung in loops from overhead trolleys to accommodate carriage motion. Structure is designed to accommodate drive motors with twice the present horsepower. Tracing system and machine controls were designed and assembled by the General Electric Company, Waynesboro, N. C. *(continued on next page)*

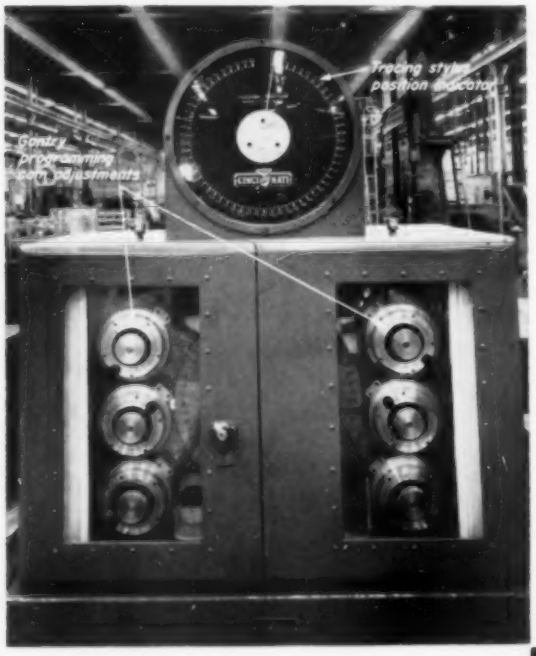
FLOOR MOUNTED CABINETS house electronic control units and amplidyne generators for all twelve tracing systems. One-dimension tracing systems were selected because controlling each cutter motion independently makes for greater flexibility when machining intricate contours. Present templet tracing system can be replaced by a numerical control system, using magnetic tapes, without major alterations to the machine. Machine is built to specifications of the Aircraft Industries Association for milling airframe spars, spar caps and similar parts. These parts are generally long and narrow and programmed cuts are made in the longitudinal direction. With four cutting heads, this machine can complete work in one setup which previously required multiple setups on more than one machine.



CINCINNATI MACHINE is used at North American Aviation, Inc., to mill wing panels for F-100 aircraft from slabs of 75ST aluminum which are 20 ft long, 5 ft wide and 2 in. thick. Up to 80% of metal in slab is removed with a horizontal 14 in. dia cutter which has removable carbide tips. Called a beam mill, the machine was developed from a prototype designed by North American. The single cutting head is carried on a beam which extends full length of work area. Beam is supported on two gantrys which move on ways transversely to the longitudinal carriage motion. A set of linear cams, mounted on the beam, control contour of each cut. The two-dimensional tracing system uses synchros and electronic error detection equipment to control hydraulic motors which position carriage and cutting head. Carriage feeds at rates up to 155 ipm. A separate synchro indexing system positions the gantrys to set correct "line of cut" for each cycle. Not all cuts are parallel. Beam can pivot on one gantry and slide, as well as pivot, on second gantry. Machine is set into a pit to place working surface at floor level.

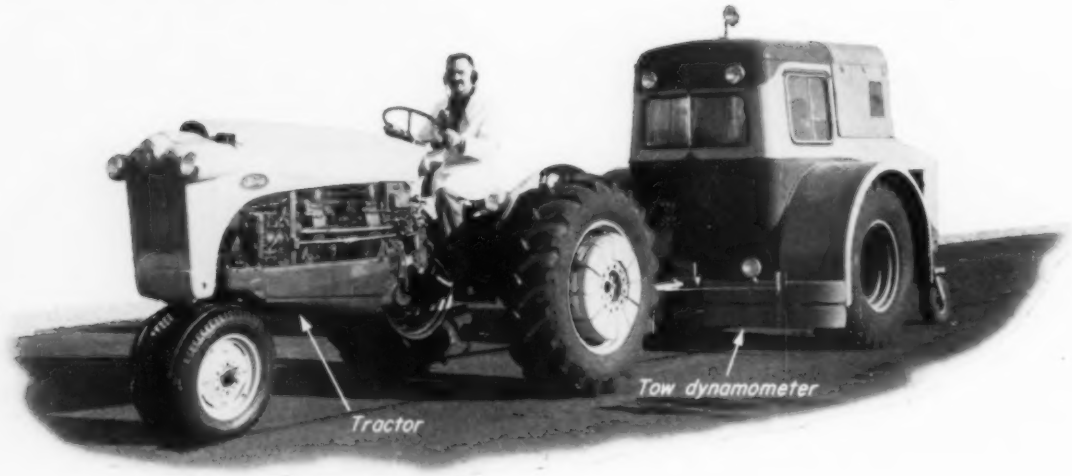
Chip disposal (9,000 cu in. per hr) was a major problem and required installation of a vacuum system. Vertical and transverse motions of cutter head are followed with a chip pickup hood while longitudinal motions are followed with a telescoping tube. Tube is made of 15 cylindrical sections, each of which is 42 in. long. Cylinders are 10 in. dia at small end of tube and 17⅛ in. dia at discharge end. Extended tube is 26 ft long; closed length is 4 ft. Chips are discharged through a swivel goose-neck tube and a second telescoping swivel tube to a collecting trench under the floor. A drag chain conveyor then carries them to storage bins.

AUTOMATIC CUTTING CYCLE is programmed from console station adjacent to machine. Controls on carriage are used only for setup adjustments. Saddle positions are programmed by setting dials in cabinet at rear which position control indexing synchros. Console at right carries controls for operating saddles, carriage and tracing system. Machine incorporates basic components for numerical control as information now obtained from templets and indexing cams can be taken from other programming devices without major changes in the control system.



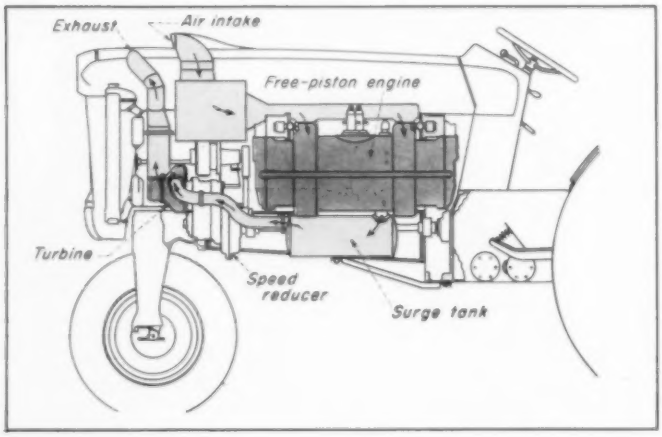
INDEXING MECHANISM POSITIONS SADDLES in relation to an arbitrary x and y axis. Operator dials coordinates which set position of each gantry in relation to the zero selected axis. This positions main beam and cutter centerline over correct "line of cut". Three dials are used to set each saddle position: coarse, medium and fine. In automatic cycle, dialed numbers are converted into synchro angles by a system of cams which can "store" up to 120 indexing positions. Coarse synchro positions represent dimensions from 0 to 140 in., medium vernier synchro positions represent dimensions from 0 to 10 in. and fine vernier synchro positions represent dimensions from 0 to 0.2 in.

CONSOLE CENTRALIZES PUSHBUTTONS, selector switches and indicating lights used by operator in monitoring automatic cycles. Controls for gantrys are at left, those for tracing system are at right. Cross slide controls are in the center. Work is placed on a vacuum chuck and located with pins in relation to machine's coordinate axes. Left and right-hand wing panels are processed sequentially using the same set of templets. In automatic cycle, sequence of tracing cuts is pre-planned. After each cut, tracing stylus is placed over next templet automatically. Any sequence and combination of gantry positions and cut contours may be selected.



Free Piston Turbine Engine Tractor

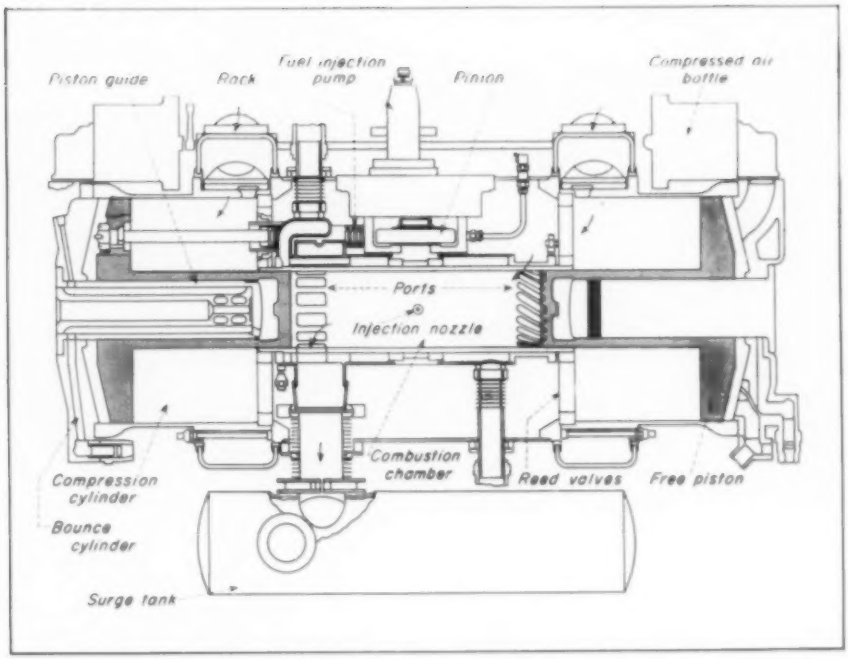
A prototype of future high-powered farm tractor with a free piston turbine engine is being tested at the Birmingham, Mich., proving grounds of the Ford Tractor and Implement Division. Driven by exhaust gases from a free-piston gasifier, the turbine runs at speeds up to 43,000 rpm and can develop over 100 drawbar hp. High horsepower and starting torque characteristic make this prime mover excellent for use in agricultural equipment. Engine is mechanically simple, easily maintained, and capable of operating on a wide range of fuels. Present tractor and engine are strictly experimental, however, and are not scheduled for actual production.



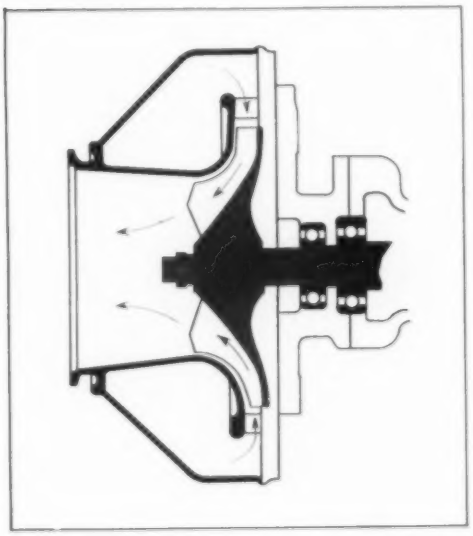
CALLED THE TYPHOON, this model will require several years of development before a production design is evolved. At present, power output is being limited to 50 drawbar horsepower. Hot gases from free-piston gas generator pass forward to turbine and are then discharged upward through dual exhausts. Turbine drives a two-stage speed reducer to which main and auxiliary drives are connected. Auxiliary drives include hydraulic systems and power take-offs for operating farm implements. Fuel economy is expected to match that obtained with automotive diesel engines. With fewer engine parts, wear is reduced and overhaul is simple. Cylinder end-plates are removed after loosening 12 bolts, exposing pistons and interconnecting racks for inspection or repair. Another feature of interest to farmers is ability to start easily at low temperatures without an auxiliary motor, spark ignition system, or warm up period.

Tractor Measurements	Gas Generator Measurements	Gas Temperatures	Gas Pressures
Length; 144 in.	Bore; 3.75 in.	Ignition; 1000 F	Air Manifold; 22–40 psi
Height; 70 in.	Stroke; 4.2 in.	Turbine inlet; 960 F	Surge tank; 16–27 psi
Wheelbase; 99 in.	Comp. ratio; 15:1	Turbine Exhaust; 750 F	Turbine inlet; 15–25 psi

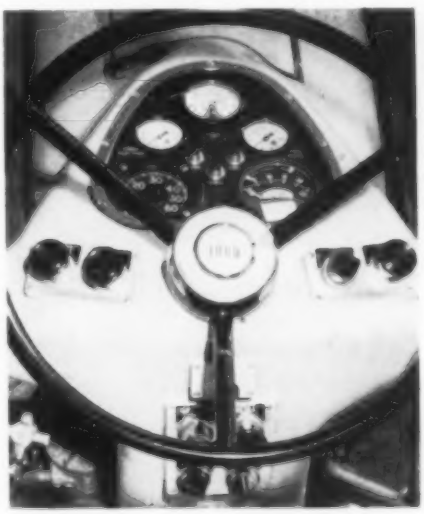
Overall speed reduction in firstgear; 5600:1



GAS GENERATOR is a two-cycle free-piston diesel engine with opposed pistons synchronized by interconnecting racks and a pinion. Air is compressed by outer area of stepped pistons and forced through radial reed valves into a manifold surrounding water jacketed combustion chamber. Ports in cylinder wall admit air to combustion chamber and discharge hot gases into exhaust surge tank from which they are piped to turbine. Air confined in bounce cylinders at ends of engine forces pistons toward center position to compress air in combustion chamber before fuel is injected. Injection pump is actuated by cam on synchronizing rack. While running, engine maintains charge in compressed air bottles used for initial compression stroke when starting. Piston supports are cooled by circulated oil.



TURBINE is a single-stage radial-inflow reaction machine with a 6 in. dia rotor which idles at 10,000 rpm. Present top speed is about 43,000 rpm but may be higher in future designs. Torque developed by turbine is transmitted to rear wheels through a special transmission which also is experimental. It has 10 forward and 2 reverse speeds and is power shifted. One major problem in developing a production machine is cost of bearings. Designers want to replace present ball bearings with lower-cost sleeve bearings.



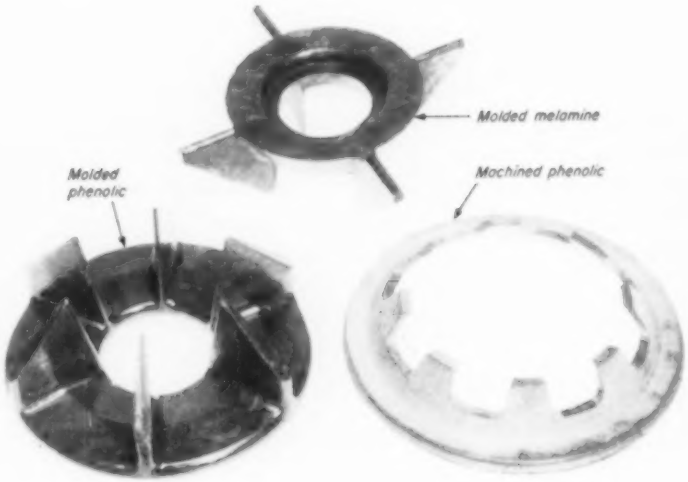
INSTRUMENTS include some not found on conventional tractors to display gasifier cycles per min, turbine rpm, turbine inlet gas pressure, fuel pressure and water and oil inlet temperatures. Indicating lights signal lack of battery charge and lubricating or cooling oil pressure. Throttle control lever and manual gear selector are on opposite sides of the hood.

SHROUD ASSEMBLY fabricated from impregnated glass fabric, using vacuum bag techniques, protects components in an ordnance device. Cone mounted in aperture to protect shroud material from localized high temperatures during operation, is fabricated from glass fiber impregnated with silicone resin.

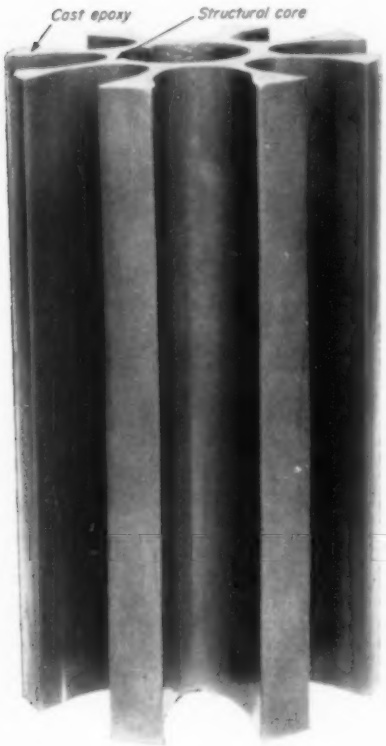
Plastic Parts in Rockets

High temperature gases impinging on rocket motor parts require use of materials or combinations which provide structural rigidity as well as resistance to heat. Flame temperatures over 1000 F and high gas velocities make reinforced plastics preferable to metal structures for many such parts used by the Structural Plastics Department of Aerojet-General Corp., Sacramento, Calif. Reinforcements are combined with polyester, epoxy, temperature-resistant phenolic or silicone resins.

LINER FOR NOZZLE ADAPTOR in rocket motor is made of glass-reinforced plastic using a modified epoxy resin developed by Aerojet, tentatively designated XSP-1. Service during operation of a safety device requires exposure to temperatures over 3000 F for several seconds in a high velocity gas stream. Fabrication costs, with the special resin, are about one-half those for a part fabricated with a conventional heat-resistant phenolic resin.



SUPPORTS FOR SOLID-PROPELLANT CHARGES with complex configurations are made from phenolic and melamine resins reinforced with chopped glass fabric, chopped glass roving, and cotton fabric. Fabrication methods include machining from stock and matched-die molding. Ability to be easily formed, combined with thermal insulating properties and high strength-to-weight ratio, makes reinforced plastics especially suited to many such applications in construction of rocket and missile components.

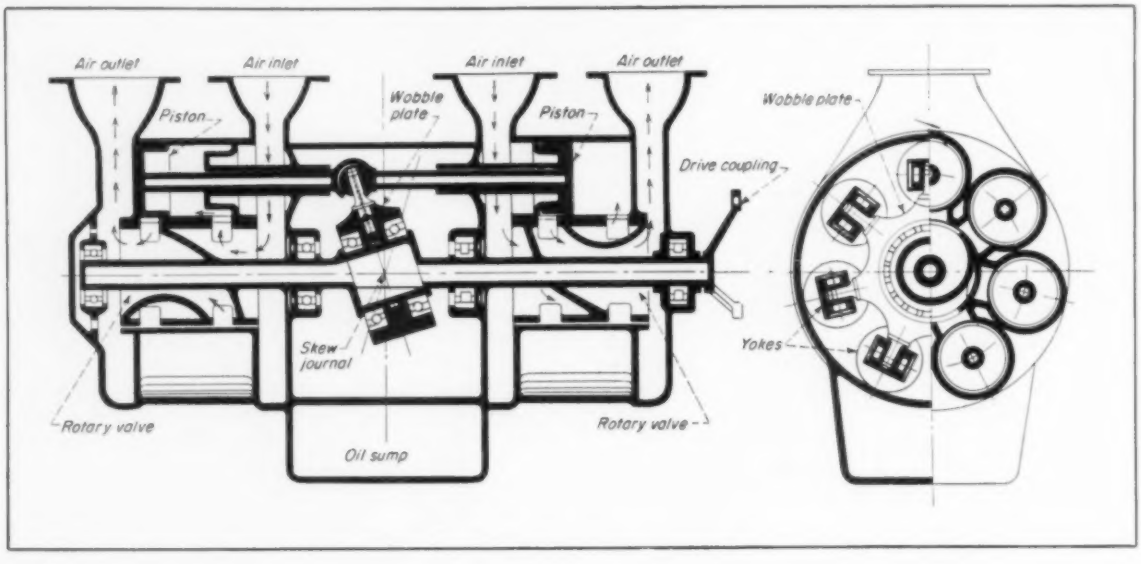


GLASS REINFORCED PLASTIC TUBE forms rigid structural core for a lightweight plastic part fabricated by casting a filled epoxy resin. Mold in which part was formed was also made of a reinforced plastic. Polyester and epoxy resins ordinarily are used for service at temperatures between −65 and +200 F. For temperatures up to 1000 F, heat-resistant epoxy, phenolic, modified polyester and silicone resins are used. Silicone resins are limited generally to parts used for long-duration exposure to high temperature gases.

THERMAL BARRIERS used in two air-to-air rocket motors are match-die molded using chopped-glass-fabric and a phenolic resin. These barriers protect metal nozzle entrances from high-temperature high-velocity gases. Using lightweight plastic parts to protect metal structures from high temperature gases saves considerable weight by reducing required thicknesses of metal parts. Some surface decomposition is acceptable as equipment is generally expendable.

Multi-Cylinder Supercharger

A diesel engine supercharger which uses a multi-cylinder arrangement of opposed double-acting pistons has been developed by Sir Harry Ricardo and Wellworthy Ltd. of England. This machine develops higher compression ratios and efficiencies than are obtained with lobe or vane-type positive displacement blowers and is designed for applications where turbo-blowers operate at a disadvantage. One application is engines with less than 500 cu in. displacement where rotor clearance problems make small turbo-blowers inefficient and costly and where poor torque characteristics are obtained at low speeds. Another application is engines in construction equipment where small gas flow at low engine speeds again lowers available torque in an operating condition where high torque is desirable.



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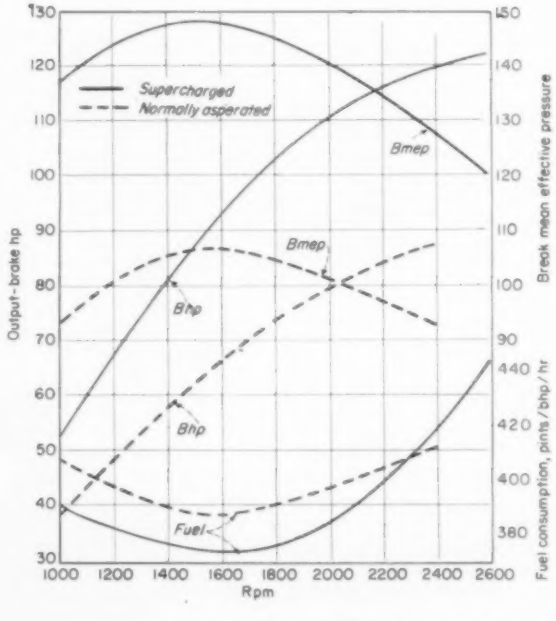
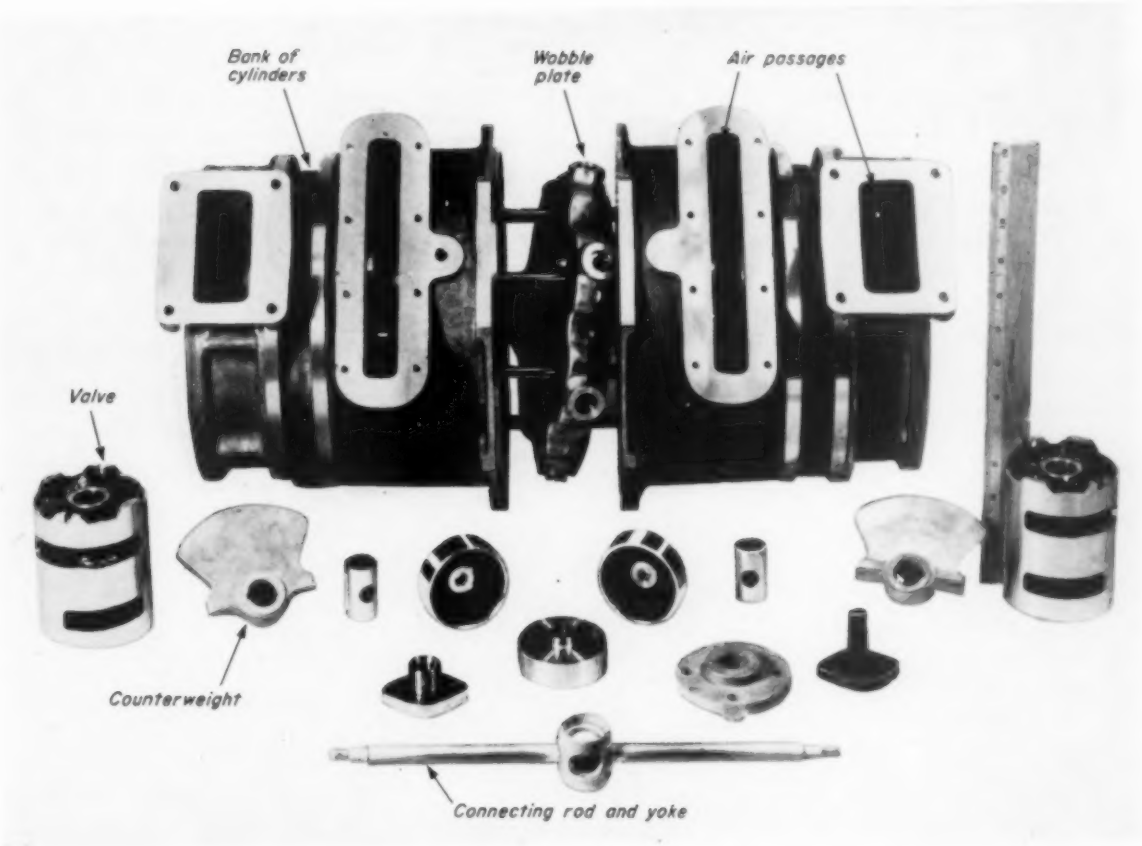
DOUBLE-ACTING PISTONS are arranged axially in two opposed cylindrical banks of seven cylinders each. Pistons are reciprocated by a wobble plate on a skew journal at center of drive shaft which is mounted on axis of cylinder-banks. Air flow is controlled by valve drums which rotate with the drive shaft and expose ports in cylinders in proper sequence. Piston rods are fastened to yokes in wobble plate which have two degrees of freedom to accommodate plate motion. Each rod is supported by two sleeve bearings carried in diaphragms on each side of wobble plate. This design prevents pistons from contacting cylinder walls and makes cylinder lubrication unnecessary. Pistons are magnesium, and are assembled with 0.001 in. radial clearance. Labyrinth sealing grooves are used on pistons instead of rings.

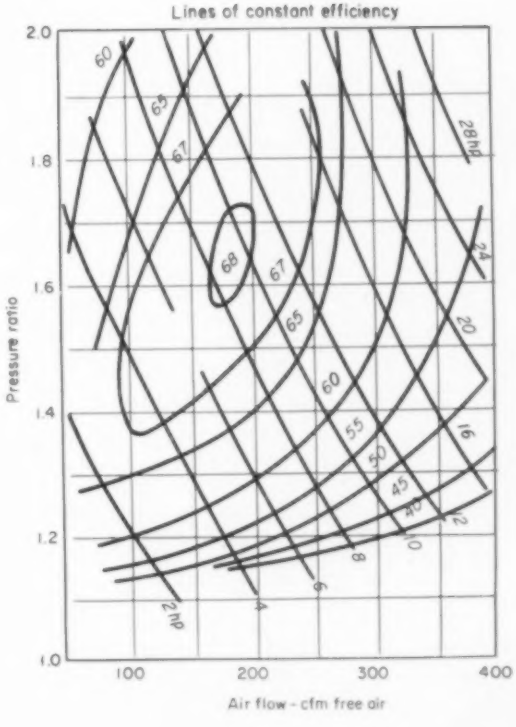
▶

OUTPUT IS INCREASED over 33% and maximum brake mean effective pressure is increased about 50% throughout range tested when supercharger is applied to 350 cu in. Leyland engine. In most economical operating range, fuel consumption is reduced about 5%. Major development effort was centered around holding fine running clearances between moving parts over a wide range of operating temperatures. Preloaded tapered roller bearings are used on drive shaft to prevent radial play from differential expansion of bearing race and housing.





▲ **PLACING CYLINDERS AROUND ROTARY VALVES** makes clearance volume between valve and cylinders small and shortens air passages. Also, this design lets one valve handle each group of seven cylinders. Air velocity is kept low throughout machine as port areas can be large. Although this machine has more moving parts than lobe or vane blowers, these parts are easily manufactured and many are identical. No critical tolerances are required.

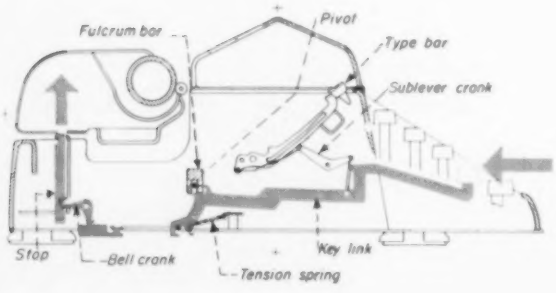


▶ **CHARACTERISTIC CURVES** show maximum efficiency contour of 68% at pressure ratios between 1.6 and 1.7. In this range, machine delivers about 180 cfm of free air while running at 2000 rpm. Spacing of contour lines indicates high efficiency is maintained over a broad operating range, including area of low flow and low speed.

Typing Keys Select Tabulating Columns

Decimal tabulation is simplified by using the bottom row of typing keys to select tabulating columns in a low-cost, light-weight typewriter made by Alpina Office Machine Co., Kaufbeuren, Germany. Moving keys horizontally selects individual stops, indicated on the space bar, to facilitate random tabulation.

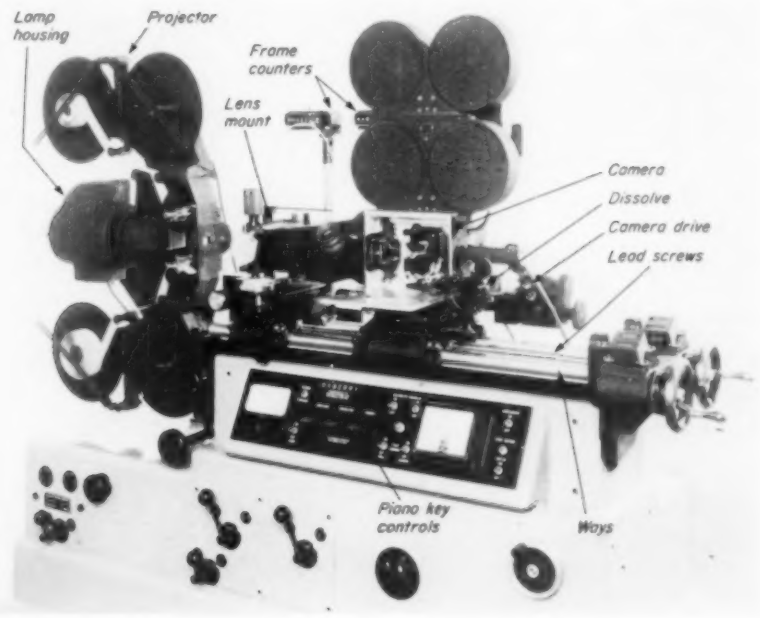
WHEN TYPING, key link is held in forward position by a tension spring, and pivots around rod which rides in slot at rear of link. Depressing key rotates sub-lever crank and throws type bar toward paper roll. Machine is converted for tabulation by adding simple mechanism at rear which raises carriage stop. Decimal calibration on space bar is only external difference between maker's tabulating and standard models. In both models, carriage is 13 in. wide.



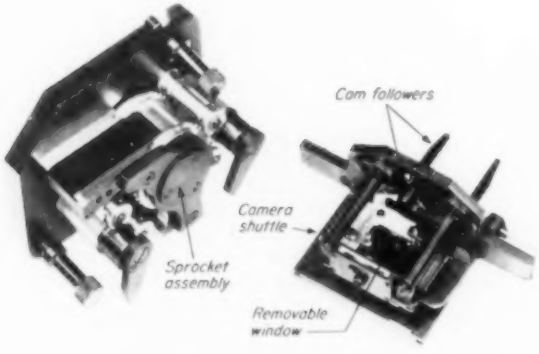
WHEN TABULATING, key is pressed back horizontally with thumb to rotate bell crank at back of typewriter and raise stop to engage carriage. Pivot pin in fulcrum bar now slides in slot in key link, and link to sublever crank swings horizontally without actuating type bar. Carriage can be set to any desired tabulating position, by pushing back proper tabulating key, without stopping at intermediate columns.

Printer Speeds Film Editing

An optical printer unusual for the ease with which it is adapted to the varied editorial requirements of film processing has recently been developed by John Oxberry at the Animation Equipment Corp. of New Rochelle, N. Y. Projector and camera are coordinated in a unit complete with indexed stop-motion and fast rewind drives which operate these devices simultaneously or independently, as required. Also, interchangeable 16 mm and 35 mm film transport components simplify film size changes.

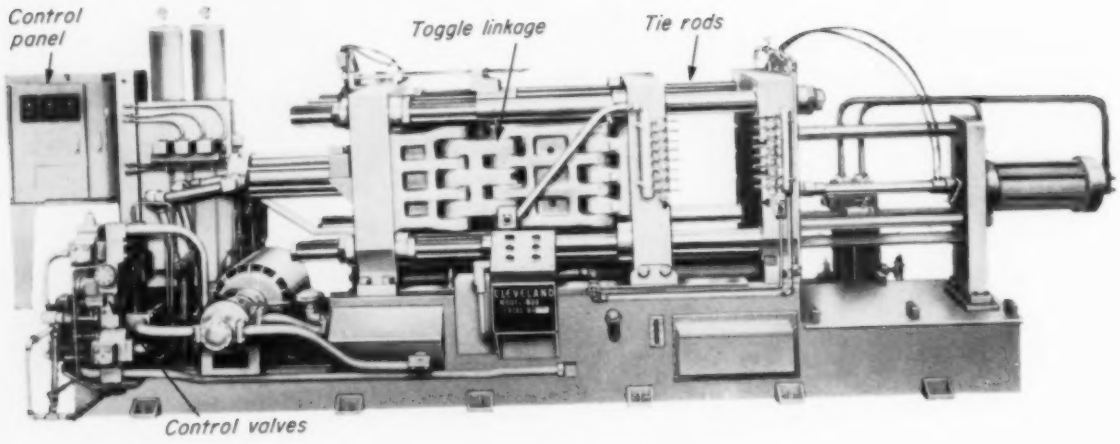


LENS AND CAMERA are mounted on cylindrical ways with roller bearings. Separate lead screws position camera and lens relative to each other and to projector to change image size for wide range "zoom" or "fade" effects. Lens mount has vernier adjustments with dial indication to facilitate alignment with optical axis of projector and camera which can be tilted for special effects. A reticle in this focusing system is calibrated with apertures for silent, sound and TV image sizes for both 16 and 35 mm film.



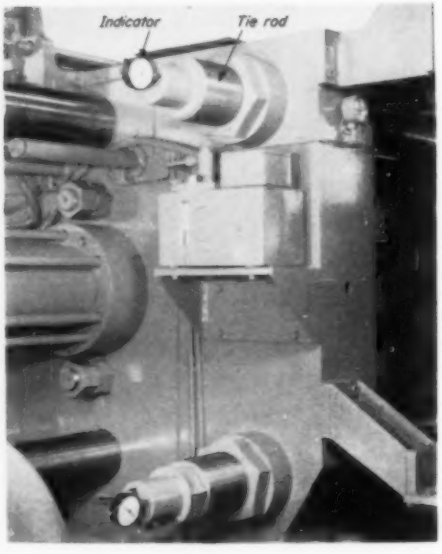
Projector and camera are equipped with two sets of reel spindles which make possible superimposing masks, special scenery or titles on film being processed. Torque motors on spindle shafts maintain tension in film as it is transported by shuttles and sprocket drives. Piano-key finger-tip controls on console actuate sensitive snap switches for simple manual control of framing action. Controls are provided also for an auxiliary projector which may be attached to existing projector after lamp housing is removed. Achromatic condensing system in light source produces 22,000 ft candles at film aperture with a 500 watt bulb.

Shuttles and sprocket assemblies in projector and camera are easily changed for 16 or 35 mm operation. This feature is important as leaving projector and camera housings in place preserves critical alignment of optical axis which is difficult if entire camera or projector must be removed. Drives were developed which meet speed requirements of both size sprockets. In camera, speed change is made in an external gearbox and sprockets engage either one of two concentric shafts. In projector, a single shaft engages both size sprockets which have internal gear reductions to obtain desired rpm. A single compound cam in both camera and projector actuates two motions in each size shuttle. Automatic dissolve action is obtained with a planetary drive which resets relative position of rotating shutter segments. Removable window in camera shuttle and a plug in the case facilitate supercritical focusing with a microscope once sprocket drive is removed.

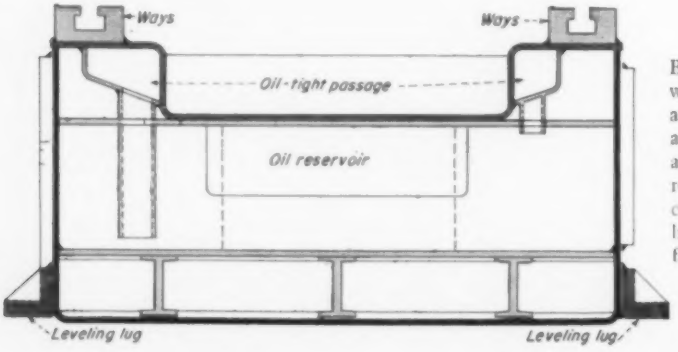


Indicators Show Tie Rod Strains

Dial indicators, permanently mounted on the tie rods of this 600-ton diecasting machine, make it possible to distribute the locking-pressure load uniformly when the machine is set up for a production run. Made by the Cleveland Automatic Machine Co., Cincinnati, Ohio, the machine has a simplified base construction and a compact arrangement of hydraulic control valves.



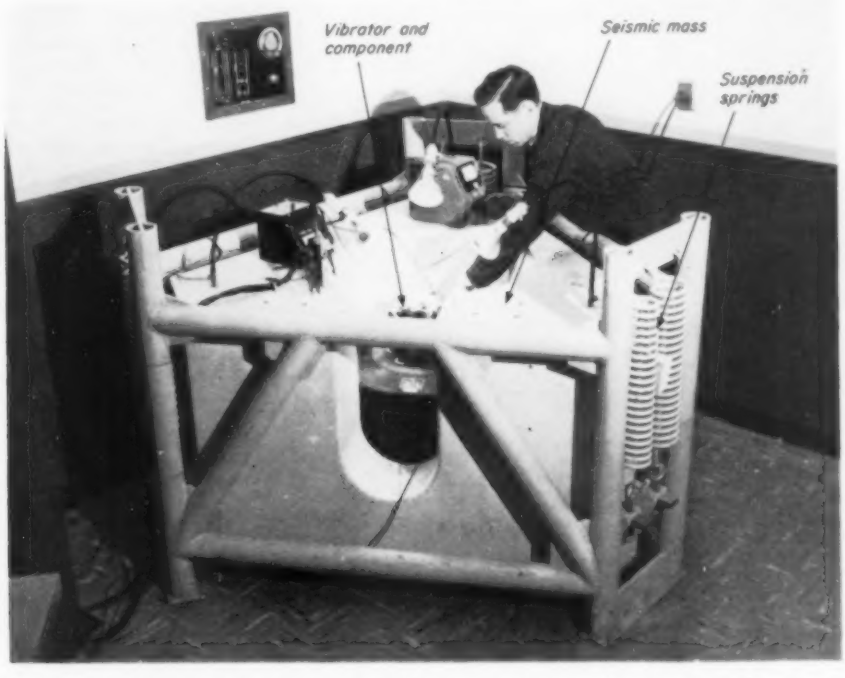
SPRING-LOADED INDICATOR RODS extend 7 ft into each tie rod so dial indication is sensitive to small adjustments; dials read directly in microinches. Accurate distribution of locking loads among the 4 tie rods is important to prevent excessive flashing. This press has cast alloy steel toggle linkage to handle the 600-ton loads. Pump capacity has been increased from 43 to 99.7 gpm, at 400 psi, and 2 accumulators are used to obtain faster cycle times. Prefabricated piping and a compact arrangement of control valves about a common manifold have lowered manufacturing and maintenance costs. Cycle sequences are timed with permanent templets which program electric circuits in the control panel.



BASE HAS BEEN REDESIGNED to require less welding by using a stressed skin construction. Bottom and sides are formed from a single steel sheet, while a second formed sheet is the top. Baffles serve as webs and gussets to increase rigidity. Oil tight passages return the hydraulic fluid to the 200-gal reservoir in center section. Adding leveling lugs facilitated assembly as well as final installation, and lowered manufacturing cost.

Seismic Mass Isolates Vibrator

To prevent random external oscillations from interfering with vibration tests on missile instruments, Boeing Airplane Co, Seattle, Wash., mounted their test equipment in a seismic mass. Previously, test results were affected by frequencies generated by passing vehicles and by sympathetic vibrations in the mounting frame. Present structure does not respond to frequencies much above 1¼ cps.



SEISMIC MASS is a triangular piece of concrete which weighs 5,000 lb and is suspended on 6 tension springs from a steel frame. Springs are mounted in pairs with coils of each pair wound with opposite helix rotation. Test vibrator is suspended on horizontal trunions in a cup-shaped pit to position it at center of gravity of concrete mass and in same plane as spring connections. Placing vibrator at center of gravity of seismic mass and use of oppositely-wound springs prevents coupling between vibrator and mount regardless of direction of vibrator axis.

A WELDED ALUMINUM DUMP TRUCK BOX has been constructed by General Machinery Co., Spokane, Wash., with an 8 to 10 cu yd capacity. Fabricated from Kaiser Aluminum high-strength alloy 5086, the dump box with hoist weighs 2000 lb less than a comparable unit made of steel.

PREFORMED STAINLESS STEEL TUBES, molecularly bonded into a cast aluminum housing, form compound-curved passages for hydraulic and pneumatic circuits in a miniaturized torpedo depth control designed for the U. S. Navy by Al-Fin Division of Fairchild Engine and Airplane Corp. Curved turns make possible smaller diameter passages than with a design using a drilled and plugged right-angle system. Also, passages are more closely spaced and require less housing wall thickness for support.

TUBULAR ROLLERS HAVE REPLACED VANES in a positive displacement pump designed by John Ayling of Ryde, New South Wales, Australia. Low friction losses and automatic adjustment for wear are major advantages of the design. Fluid which enters rotor slots behind rollers is forced into discharge port when rollers re-enter slots.

INTERCHANGEABLE BORING HEADS with multiple spindles which can be arranged with center distances of ¾ in. have been designed by the Heald Machine Co., Worcester, Mass., for use on a precision boring machine assembled with modular units. All spindles are driven with a single timing belt from a motor on top of the head. Belt drive allows spindles to be positioned at various center distances or to be omitted if not required for a specific job.

A TEFLON-GLASS FIBER CLAMPING PAD is used to seal both plastic and barrier materials in a new semi-automatic heat sealing machine made by Product Packaging Engineering, Culver City, Calif.

HIGH TEMPERATURE BEARINGS for afterburner hinges of the General Electric J-47 gas-turbine jet engines use rollers made from cobalt-base alloy wire.

Fig. 1—Design based on standarized mechanical building blocks assembled into functional chassis reduces complex equipment to small, readily removable and replaceable units and simplifies servicing and minimizes equipment downtime. This is a facsimile weathermap recorder designed with modular units.

JOHN ALDEN, *Vice President*
Alden Products Company

MODULAR ELECTRONIC

Downtime is minimized, prototypes closely resemble production models, and basic layouts serve both engineer and user, when the "electronics" is in building blocks.

ELECTRONIC equipment mechanically designed around a series of standard building-block elements simplifies design and production and provides maximum utility and reliability. These building blocks are standardized phenolic-laminate card subchassis, metal chassis, panels, racks and cabinets; they are combined in a plug-in type construction based on division of electronic equipment into panels and chassis which each perform an important electrical function. Sectionalizing produces smaller units easier to service and maintain.

To provide the basic fabrication and assembly plan which will give a logical arrangement of the various parts, chassis, and panels, Fig. 1, major functional units of the proposed equipment are derived from a master block diagram, left in Fig. 2. Each of these large blocks represents a complete functional chassis which can be plugged into or removed from a main rack or frame, as in Fig. 1. From each large block smaller functional blocks are derived, as shown by the dashed enclosures at right, in color. These smaller blocks represent the phenolic-laminate cards.

Use of the phenolic-laminate card as the basic structural element has several advantages. First, it provides a structure on which parts can be mounted and organized in a single plane. Mounting these cards in vertical planes in the chassis provides for more efficient heat removal. They are readily adaptable to hand or to printed wiring. Also, these cards provide maximum similarity between prototype and production model because they can be used in both.

Typical phenolic cards are made in modular sizes, usually in 2-in. increments up to 2x16 in. This maximum length can be used in equipment assembled in standard 17-in. relay racks.

For prototype designs, it is desirable to use cards with punched holes. The examples shown have 0.10-in.

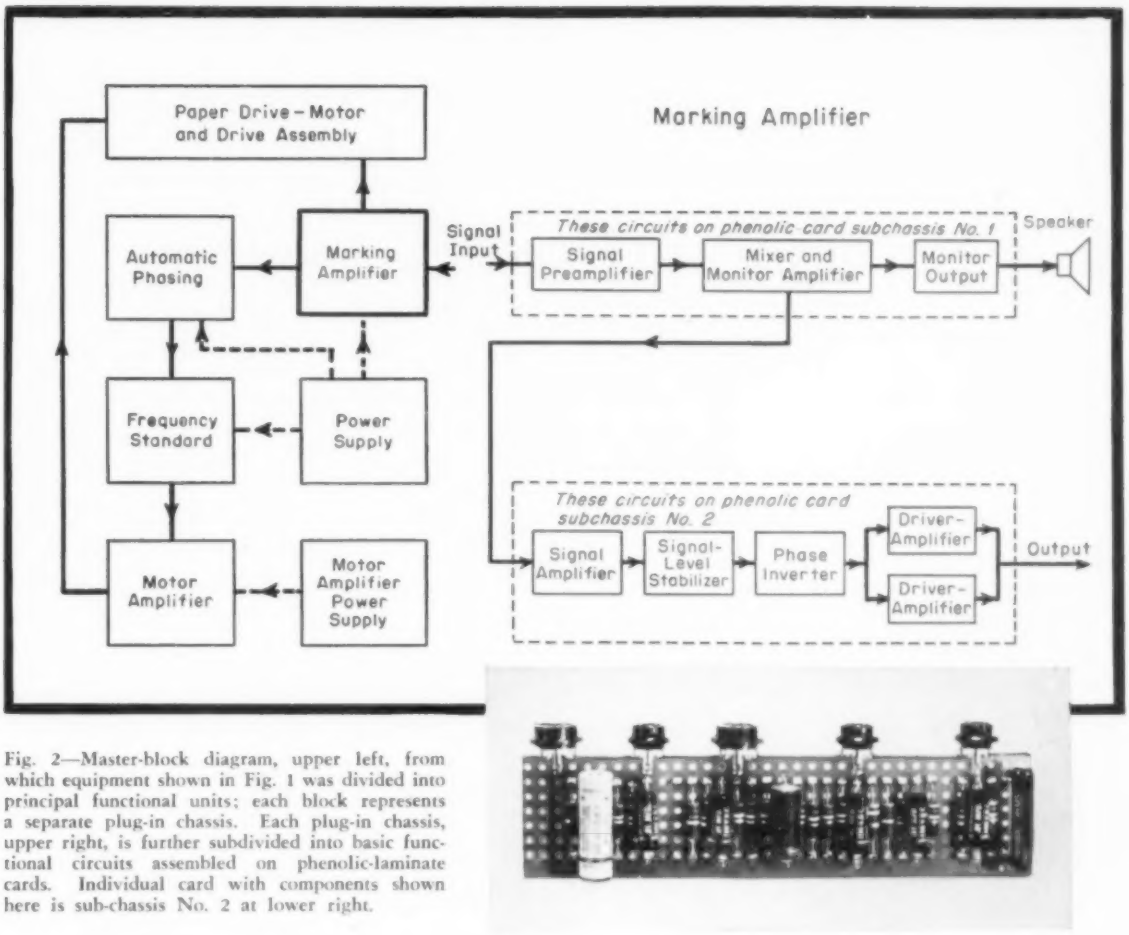


Fig. 2—Master-block diagram, upper left, from which equipment shown in Fig. 1 was divided into principal functional units; each block represents a separate plug-in chassis. Each plug-in chassis, upper right, is further subdivided into basic functional circuits assembled on phenolic-laminate cards. Individual card with components shown here is sub-chassis No. 2 at lower right.

UNITS — *cut time all along the line*

holes on 0.25-in. centers. These holes are primarily used, at this stage, for flexibility in mounting and connecting various sizes of resistors, capacitors, and other components. However, it is often desirable to retain this type of card in the production model because of improved ventilation and heat transfer, and also easy duplication of the prototype in production.

Planning Sheets

A planning sheet, Fig. 3, which matches the punched boards, allows makeup of a physical layout on paper before the prototype is built. These planning sheets minimize design time and also provides an electrical schematic and a mechanical wiring diagram which can often be incorporated directly into maintenance and service manuals with saving in cost.

From the electronic designer comes this schematic diagram, parts list, and wiring diagram, together with special notes, such as required shielding and connections to other cards or parts. From this, the parts are mounted on the front side of the board, while the wiring, for hand-wired models, is on the rear.

To fasten parts to the terminal board, split-type terminals permit insertion or removal of component lead wires for ready shifting or substitution during prototype layout and construction. This type of terminal is staked to the board and requires minimum space.

Two types of vacuum-tube sockets are used with phenolic cards, side-mounting or straddle. Where vertical dimensions must be a minimum, side-mounting sockets can be applied as shown in Fig. 4; here printed wiring is used. When horizontal space must be minimized, the sockets with a straddle-type mounting are riveted to the top of the card assembly, upper left in Fig. 5. Here the components are to be hand wired.

Card Mounting

If the card is not intended to be removed from the chassis, it may be fastened in place with standard mounting brackets and hardware. Where it is desired

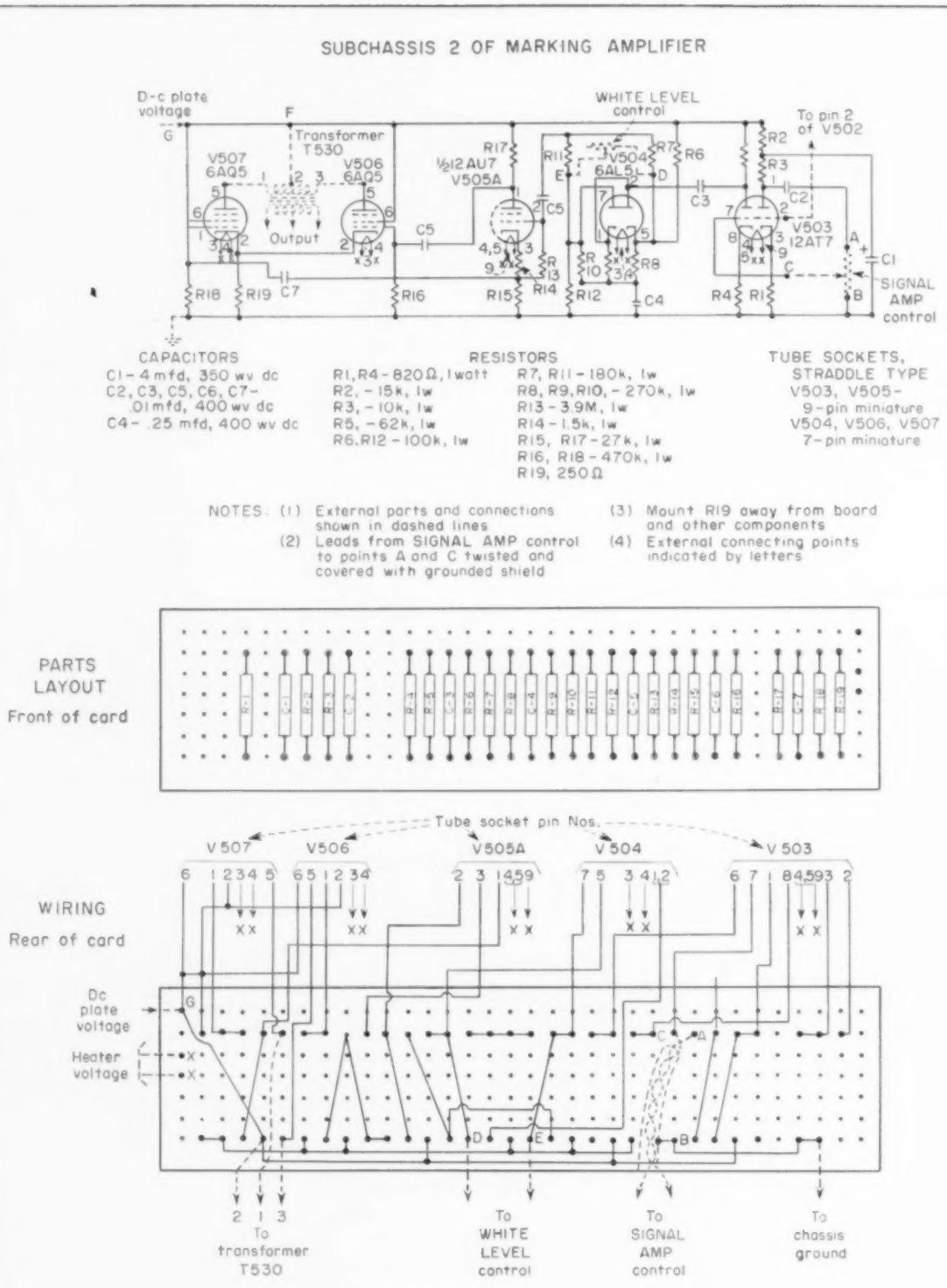


Fig. 3—Complete planning sheet for the card subchassis of the Marking Amplifier, Fig. 2. When prepared in this manner, schematic, parts list, parts location and wiring diagram may be directly incorporated as a part of the maintenance manual for the equipment.

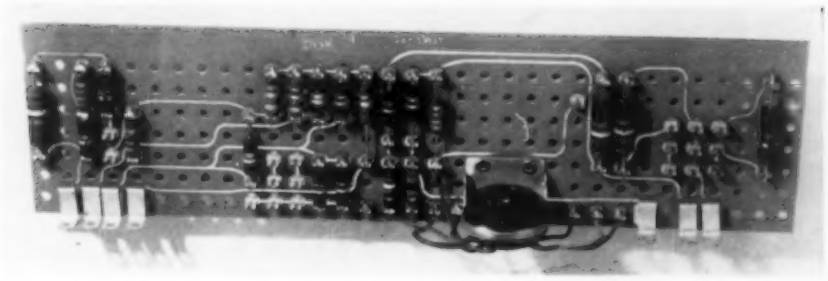


Fig. 4—Card with side-mounting socket to minimize vertical space. Printed wiring is used on this card together with plug-in mounting to the chassis.

to remove the card for checking, servicing, or replacement, plug-in spring-clip connectors shown at bottom of card in Fig. 4 may be used. Where the equipment will be subject to shock or vibration, permanent mounting may be required to provide maximum reliability.

Size of the metal chassis on which the cards are mounted depends upon the number of cards and size of other components which must be assembled to form a main functional unit. The Marking Amplifier example, Fig. 5, has two card subchassis, one with three tubes, the other with five. But the heavy transformer is the component that requires the larger metal chassis.

DESIGN FOR MINIMUM DOWNTIME

For industrial electronic equipment, provisions for detection and location of equipment failure should be included. This can be accomplished by mounting monitoring lights on each panel, Fig. 6, connected to indicate proper or improper functioning of each chassis. A color code for the lights will pinpoint trouble. For example, red can be used to indicate line voltage; green the plate voltage; yellow or amber the filament voltage; and white, blue, and violet, other signal or operating functions. Fuse-holders which light when a fuse blows also aid in spotting trouble immediately.

Test plugs or jacks shown should, in addition, be mounted on the panel as test points to permit measurement of circuit voltages without disassembly or removal of equipment. These can also be color-coded to identify critical voltages.

To minimize downtime, provision must be made for rapid replacement of a faulty chassis. This is accomplished by designing all the separable chassis with plug-in connectors at the rear. Wiring from chassis to chassis is a part of the main rack or cabinet housing the complete equipment. To fasten the chassis to the frame, quick-release fasteners should be used. Cam-actuated locking bars will provide strength, durability,

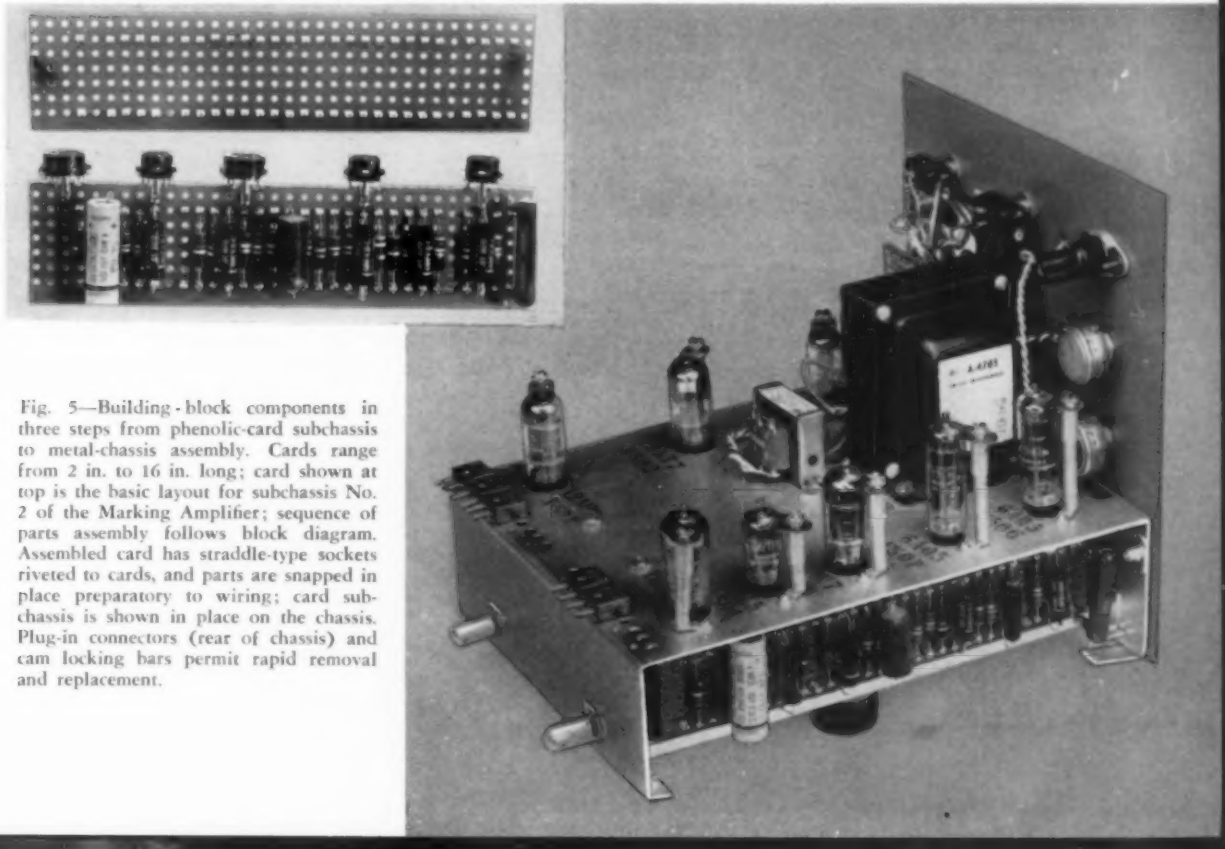


Fig. 5—Building-block components in three steps from phenolic-card subchassis to metal-chassis assembly. Cards range from 2 in. to 16 in. long; card shown at top is the basic layout for subchassis No. 2 of the Marking Amplifier; sequence of parts assembly follows block diagram. Assembled card has straddle-type sockets riveted to cards, and parts are snapped in place preparatory to wiring; card subchassis is shown in place on the chassis. Plug-in connectors (rear of chassis) and cam locking bars permit rapid removal and replacement.

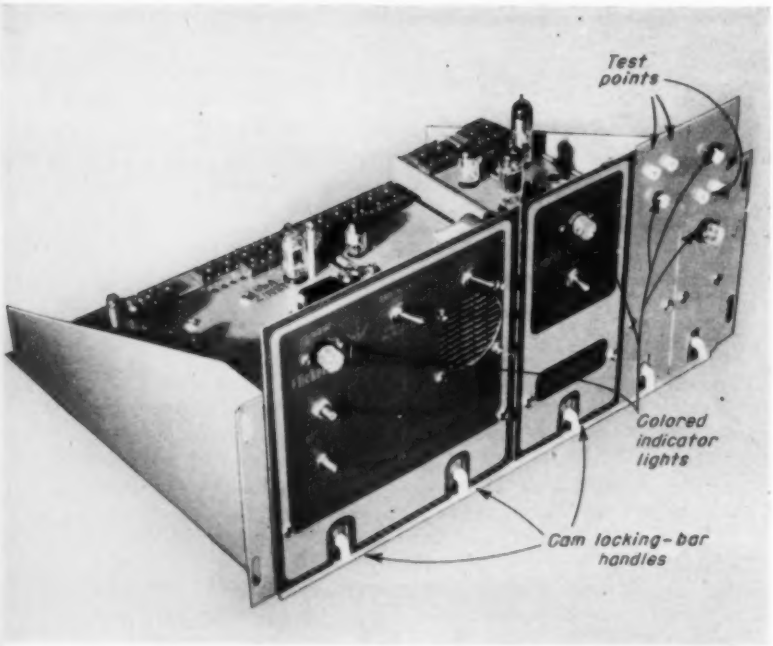


Fig. 6—Four building-block chassis combined to form complete functional panel. Cam locking-bar handles are located at bottom for easy removal of each chassis. Each chassis has colored lights, test points, or both, to indicate proper operation or malfunction and to permit operating test of chassis without removal of main panel.

and rapid insertion or removal. These bars extend the length of the chassis and are terminated on the front panel in a lever. One-half twist of this lever engages a cam in a slot at the rear and locks the chassis in place.

Size of each functional unit should be minimum; weight should be preferably less than 25 lb to permit relatively easy servicing and handling. This makes a unit which can be readily shipped to the user for replacement, particularly if he has no specialized service group.

Where possible, the equipment should be designed with functional chassis which can be used in more than one section of the equipment, Fig. 7. For some equipment, this may be on a chassis level or it may be a complete panel. Such duplication means the user can stock spare units for immediate replacement with minimum cost. Where the user has the properly qualified technical personnel, a faulty unit can be replaced with a stock spare and the improperly working unit repaired.

EDITOR'S NOTE: Previous articles discussing cabinet and structural design considerations are: "Designing the Product to Suit Human Dimensions," September 1957 page 166; and "Cabinet Design for Complex Equipment," June 1955 page 17. The latter article describes basic types of construction developed for electrical and electronic equipment applicable to housings for mechanical components.

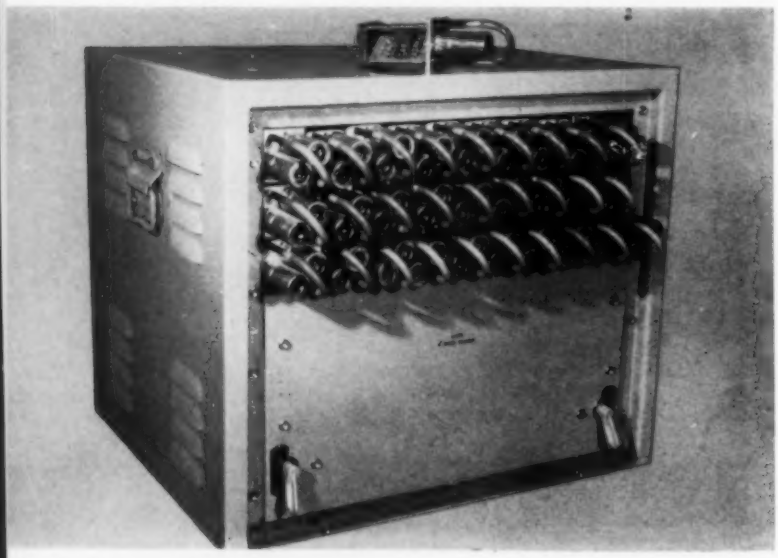


Fig. 7—Division of equipment into smaller functional plug-in units minimizes cost of standby replacements. Here, each chassis consists of a card subchassis, mating plug, one or two tubes, and a handle; each vertical row performs a separate function. Because each assembly is too small for use of printing to identify function, handles are color-coded.

SHADED-POLE MOTORS

bridge the gap between flea-power and small fractional-hp motors

R. E. SCHUETTE, *Manager of Electrical Development*
C. G. JOHNSON, *Development Engineer*
Barber-Colman Company

Recent design advances and added applications have made these units available in larger sizes—up to 1/6 hp. Here's a summary of what they are, where they're used, and how to use them.

SHADED-POLE motors are available in two basic forms, the open-core type Figs. 1(A) and (B) and the enclosed shell type (C). In the core type the field coil is concentrated on a single leg of the core, simplifying construction and reducing cost. Most core-type motors are two-pole, Fig. 1(A), and have an output shaft located off center. Where this feature is undesirable, four-pole core-type motors, (B), are available with a centrally located shaft.

Shell-type motors, (C), have a distributed winding and usually have four or more poles; also, the shaft is centrally located. Although the illustration shows an open-type shell construction, a completely enclosed motor may be obtained when required. For shell-type motors, leakage flux and the external magnetic field around the motor is substantially less than with a core

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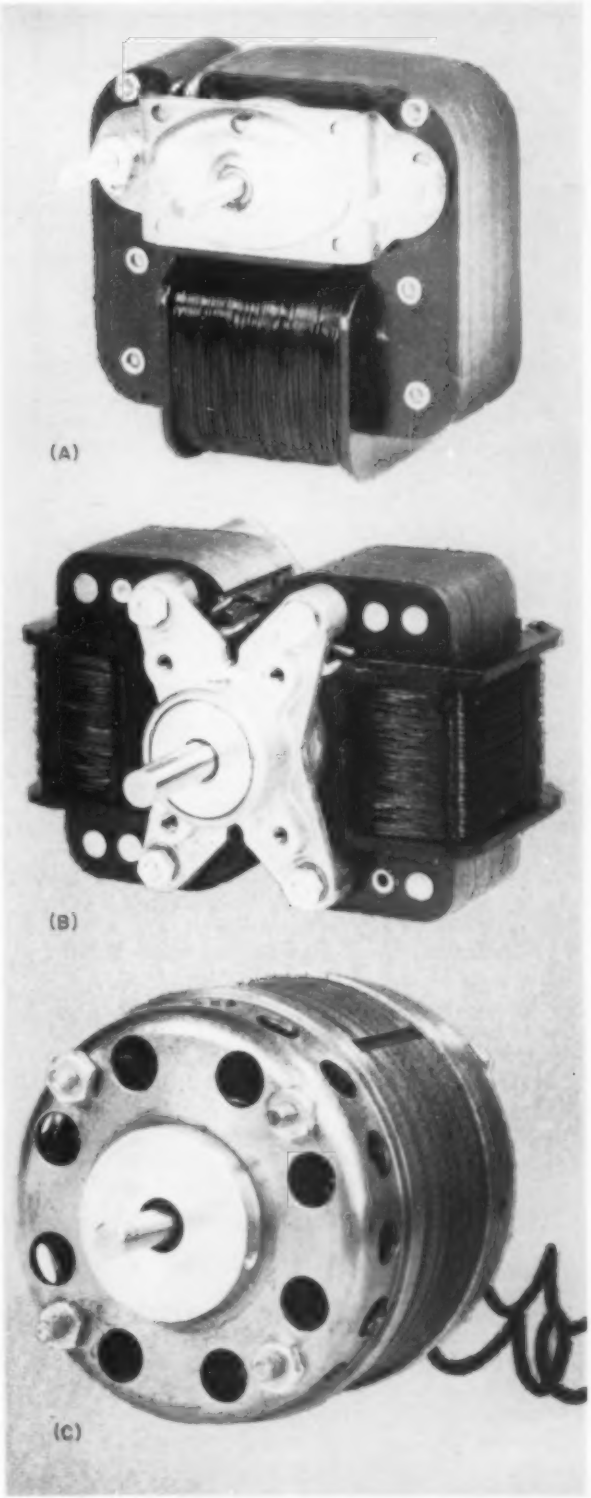


Fig. 1—Core-type and shell-type shaded-pole motors. (A) Two-pole motor with single field winding. (B) Four-pole motor with double field winding. (C) Shell-type of motor with distributed winding.

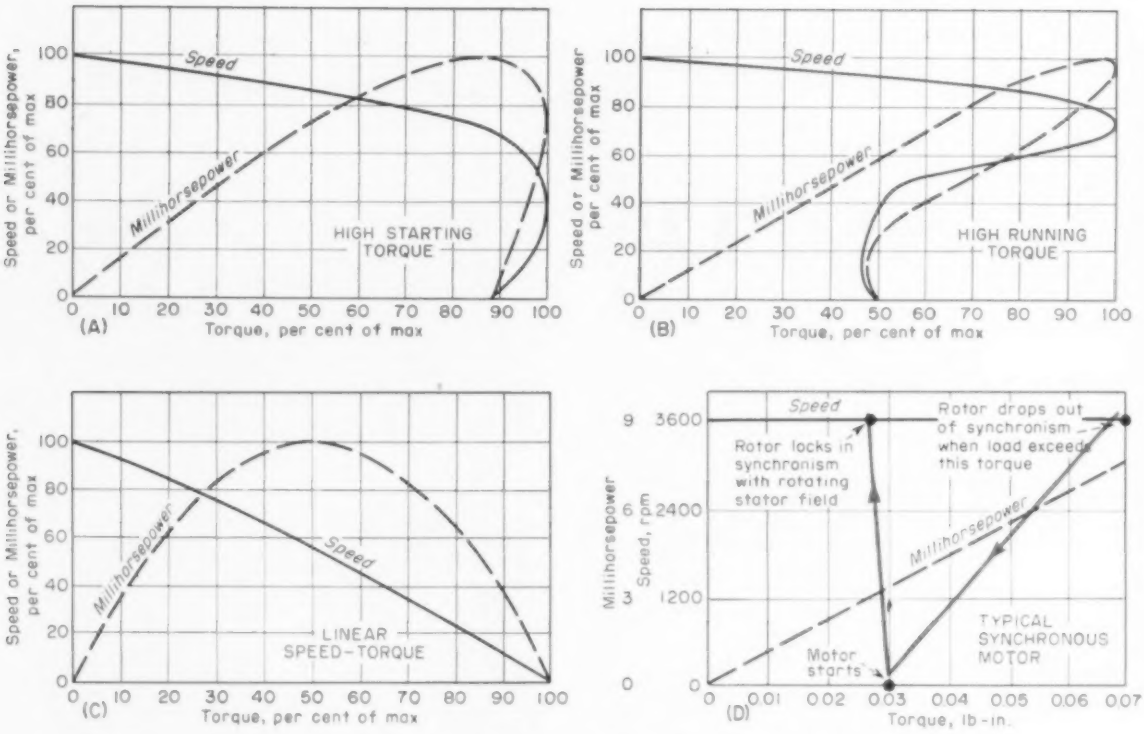


Fig. 2—Typical speed-torque characteristics of unidirectional shaded-pole motors. (A) High starting torque; (B) high running torque; (C) linear speed-torque; and (D) synchronous-motor operation.

type motor. In applications such as record players and tape recorders where these external magnetic fields may produce undesirable hum voltages, the enclosed type is required. Because of the greater number of field windings and other factors, the enclosed motor is more costly than the open-core.

Shaded-pole motors are limited to the fractional-hp sizes because of their low efficiency. In the smaller sizes, the low efficiency of usually a few per cent is of minor significance, because operating costs are negligible and mechanical factors primarily govern the size. Shaded-pole motors also have a relatively poor power factor compared to other types; in applying the larger sizes, the effect of this low power factor should be carefully evaluated.

UNIDIRECTIONAL MOTORS

Two rotational classes of shaded-pole motors are available, **unidirectional** and **reversible.** The core and shell types, Fig. 1, are unidirectional nonsynchronous motors; however, any of these can be converted to synchronous motors by changing the rotor from a squirrel-cage to one having distinct or salient poles.

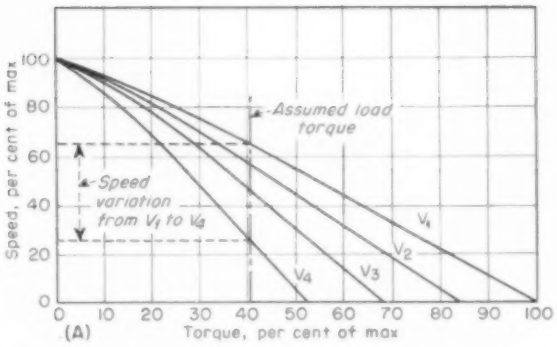
Unidirectional motors have four typical speed-torque characteristics: high starting torque, Fig. 2(A); high running torque, (B); linear speed-torque, (C); and synchronous-motor torque, (D). Typical values of starting and running torque, full-load speed, and power output of these motors are in Table I.

Because of the low output of these motors, matching the motor to the load is more critical than with larger units. For example, if the load to be driven is primarily friction, a high starting torque, Fig. 2(A), may be essential to overcome static friction on starting. For fan loads, torque increases as the cube of fan speed; here a low starting, but high running torque, Fig. 2(B), is desirable.

In some cases it may be necessary to adjust motor speed by varying the applied voltage, and for such an application a motor with a linear speed-torque curve, Fig. 3 (A), has a substantial advantage. With this type of motor the torque from synchronous speed to stall varies with a given line voltage as shown. For a reduction in voltage, maximum speed remains about the same, but maximum or stall torque is reduced. For example, assuming load torque remains constant, speed varies between the limits shown by the intersection of the dashed line with maximum voltage V_1 (115v) and a substantially lesser voltage, V_2. Should load torque vary somewhat with speed, the results are not appreciably changed.

For motors with high running torque, variation of speed with voltage is substantially lower. If the application is a recorder drive requiring constant speed, a motor having a high-running torque, Fig. 3(B), should be selected and operated at a small percentage of full-load torque. In this manner, voltage fluctuations, load variations, or other changes will have minimum effect on the speed.

If rapid acceleration of the load is essential, a motor having low rotor inertia and high torque should be



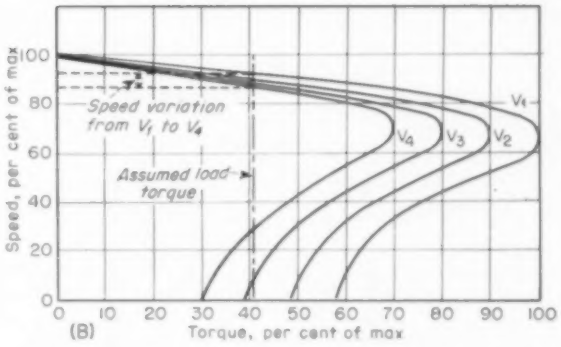


Fig. 3—Effect of change in voltage on shaded-pole motor speed and speed-torque characteristics for shaded-pole motors with: (A) linear speed-torque characteristics and (B) high running torque. Linear motor is used where speed is varied by changing supply voltage. For essentially constant speed despite change in voltage, high-running-torque motor, lightly loaded, is used. V_1 represents standard motor voltage, while V_2, V_3 and V_4 are progressively lower voltages.

chosen. Conversely, if the motor will be subject to transient overloads, such as shock loading, a high-inertia rotor should be specified to utilize the kinetic energy of the rotor. If a gear train is used, it must be designed to withstand the transient overloads.

REVERSIBLE MOTORS

Unidirectional motors are wound with one shading coil at the top of one pole face and the other shading coil at the bottom of the other pole face. By winding coils both at the top and bottom of both pole faces, the motor becomes reversible, Fig. 4. Shorting the top coil on one pole and the bottom coil on the other causes the motor to run in one direction; if these two coils are open-circuited and the other two coils shorted, the rotor revolves in the opposite direction.

The simplest method of controlling direction of rotation is to use a single-pole, double-throw switch connected to short-circuit one pair of shading coils or the

Table I—TYPICAL CHARACTERISTICS OF 115-v, 60-CYCLE SHADED-POLE MOTORS

	Motor Type	Starting Torque, lb-in.	Running Torque, lb-in.	Full-Load Speed, rpm	Power Output, hp x 10^{-3}	Typical Application
UNIDIRECTIONAL	High Starting Torque	0.05 0.14 0.21 0.34 0.49 0.70	0.04 0.11 0.17 0.34 0.49 0.70	1700 2300 2350 2900 2950 2950	0.9 4.0 6.5 16.0 23.0 33.0	Gear train, friction, and cam loads; stalled-motor applications
	High Running Torque	0.18 0.28 0.40 1.00	0.31 0.50 0.80 2.10	2900 3000 3000 2800	14.0 24.0 38.0 100.0	Fans, blowers, pumps, recording apparatus, turntables, small power tools
	Linear Speed Torque	0.13	0.07	1550	1.6	Controls and instruments using a shaft speed proportional to voltage
	Synchronous	0.02 0.04 0.06	0.08 0.13 0.15	3600	4.3 7.4 8.6	Timing devices, constant-speed applications
REVERSING		0.03 0.08 0.22 0.65	0.02 0.05 0.18 0.40	1450 1350 2000 2000	0.4 1.0 5.5 13.0	Actuating devices, recording instruments

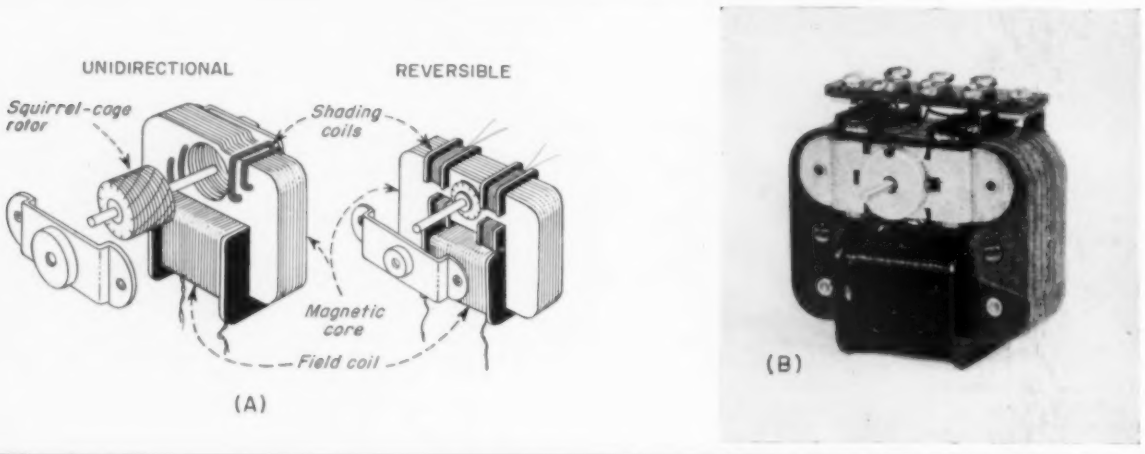


Fig. 4—(A) Comparison of unidirectional and reversible motor shading-coil arrangements. (B) Reversible shaded-pole motor with multiturn shading coil windings. Methods of control are shown in Fig. 5.

other, as in Fig. 5(A). A second method of reversing rotation uses a double-pole double-throw switch connected as in (B); applying line voltage through a capacitor to the four shading coils in series, shown in (C), increases torque 200 to 300% of that obtained by standard shading-coil operation.

Use of a center-tapped field coil with a single-pole three-position switch, as in (C), also provides two to three times standard torque but does not require an additional switch to disconnect the motor during OFF periods, as with (A) and (B).

Because of the low power required by the shading coils, usually in the order of 3 watts, the output of a vacuum tube amplifier can be used for control, (D). This method is useful for applications in which a torque proportional to a small driving signal is required, such as for remote control or servo applications. Using an amplifier, a 60-cycle transducer signal in the order of microwatts or milliwatts may be used to control motor output and rotation.

DUTY-CYCLE RATINGS

Integral-hp motors of standard NEMA specifications, have, for a frame and design type, a maximum torque and hp rating based on continuous full-load operation.

Why A Shaded-pole Motor?

Shaded-pole motors were once limited to the very small sizes, generally under 1/100 hp; today they constitute a large percentage of the fractional-hp motors installed. Recent advances in motor design and new applications, such as room air conditioners, have resulted in the use of these motors in sizes up to 1/6 hp.

The shaded-pole motor is a salient-pole, single-phase, induction motor with a conventional squirrel-cage rotor. A rotating field for producing starting torque is obtained by means of shading rings or coils. The coil usually consists of one or more turns of copper which encircle a portion of the pole face. For the reversing motor, two multi-turn coils are used on each pole face. In all cases, the alternating magnetic field, produced by energizing the main motor winding, induces a current in the short-circuited shading coil; this current in turn sets up a magnetic flux which lags the main flux and produces a rotating magnetic field.

The shaded-pole motor has no brushes, contacts, capacitors, or moving switch parts; is relatively simple, inexpensive and dependable device. They are one of the most widely used types of all motors.

Typical Applications

Small machine tools
Recorder-pen drives
Fans and blowers
Motion-picture and slide projectors
Micro-film cameras
Business machines
Food mixers
Vaporizers
Servo-mechanisms
Vending machines
Cam-operated machines
Rotisseries
Ice-cube machines
Egg graders
Flight simulators
Fatigue machines
Automatic weighing machines
Phonographs and tape recorders
Industrial controls
Humidifiers
Automatic erasers

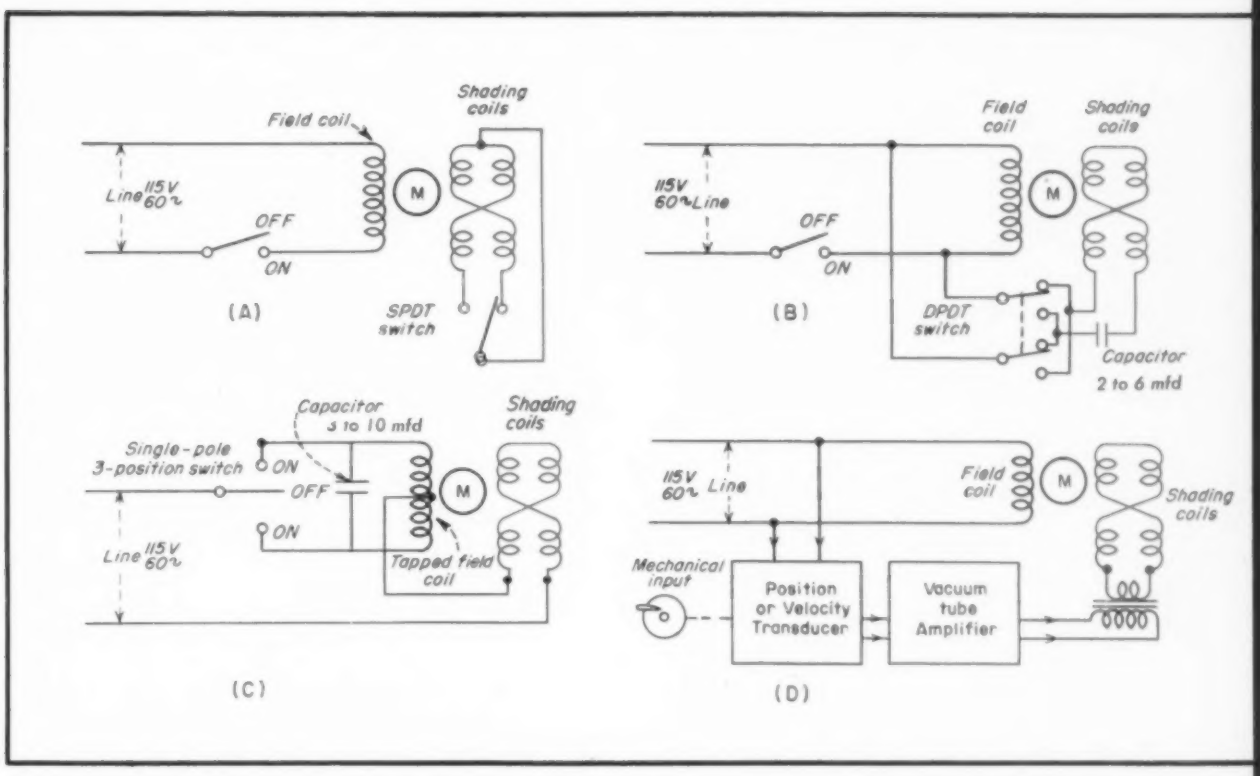


Fig. 5—Four methods of controlling reversible motors. (A) Standard reversible shaded-pole motors can be reversed by shorting one pair of shading coils, or the other, using a single-pole double-throw switch. Reversing action is rapid because of the reversed rotating field. (B) By applying the line voltage to the shading coils in series, through a capacitor, motor torque may be increased 200 to 300% over normal operation. Reversal is obtained by reversing phase of applied line voltage through double-pole double-throw switch. (C) Use of a special center-tapped field coil and a capacitor provides optimum performance. Torque is 200 to 300% that of a standard motor, as in (B). The single-pole three-position (center position OFF) switch eliminates line switch normally required. (D) Electronic control of motor operation. For best performance, current in the shading coils should be in quadrature with that in field coil. The input to the amplifier is a 60-cycle control voltage which can be taken from various type transducers, depending upon the control system used. Here, the amplifier output is applied to the shading coils through a transformer. The motor is reversed by reversing the phase of the input signal with respect to the line voltage. This may be done with a switch, relay, or the transducer.

Frame sizes of shaded-pole motors are not standardized; the output power from each frame is determined by the input power. For this reason, it is standard practice to show more than one output for the same motor, Fig. 6; this variation in power is obtained by changing the motor winding at the time of manufacture.

Lowest rated power input for a given shaded-pole motor is for continuous-running or stalled operation. For short-time running operation, higher power inputs increase the output but also increase temperature rise. If the higher power is applied continuously with no special provisions for removing the extra heat, motor temperature will be excessive. Manufacturer's data usually gives an allowable duty cycle, or per cent ON time which the motor can be operated without exceeding normal temperature rise for class A insulation, Table II. If the increased running power is required continuously, overheating may be prevented by means of a cooling fan on the rotor shaft, or by immersing the entire motor in oil. In the latter case the size of the motor is increased by the necessary sealed case.

Standard shaded-pole motor ratings are usually for 115-volts, 60-cycles ac, but by changing the field winding they can be used with other voltages and frequencies. For higher or lower voltages these motors have substantially the same output as the 115-v units, but the speed and output vary almost directly with a change in frequency.

MECHANICAL CONSIDERATIONS

Method of connecting the motor to the load is a prime consideration. If gearing is required it may be an integral part of the equipment, or it may be obtained as an integral part of the motor. While standard gear reduction ratios usually run from about 30 to 1 to 450 to 1, special designs have been made with reductions from 2.5 to 1 to over 1,000,000 to 1. If a gear-head motor is used it can be either open or enclosed, depending upon environment and type of equipment.

Minimum size and weight of motor can best be obtained by using a motor having maximum efficiency

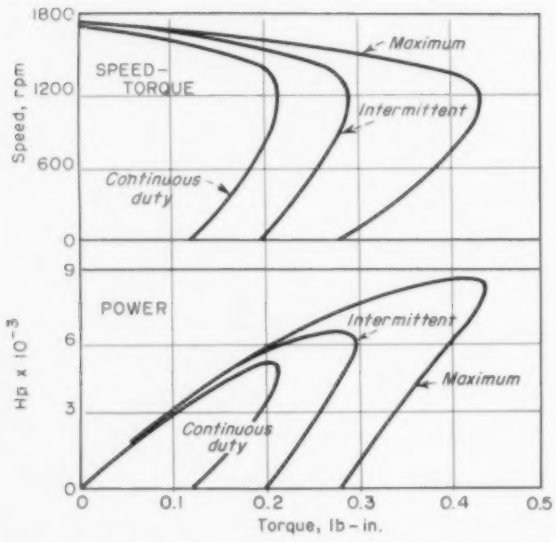


Fig. 6—Variation in power outputs obtained by using three different windings on same motor frame without special cooling means. For continuous-duty rating, motor may be stalled indefinitely. If fan is used, continuous-duty rating can usually be applied to intermittent and maximum-duty outputs.

Questions to Answer in Specifying Shaded-pole Motors

1. What are speed-torque characteristics of load?
2. What maximum torque and power are required?
3. What is motor speed or output shaft speed?
4. What are voltage and frequency of supply?
5. What is duty cycle?
6. What are mounting requirements?
7. What are space and weight limitations?
8. What kind of bearings—ball or sleeve?
9. What special environmental conditions exist?
10. Is quiet operation required?
11. What are preferred shaft dimensions and direction of rotation?

and highest power input for the task. For example, if the application requires intermittent operation, motor size will be minimized by using an intermittent-rated motor rather than a large one with a continuous rating.

Mounting devices furnished on the motors as standard parts should be used because special mounting hardware increases motor cost. In general, these motors should not be mounted on a steel plate because of a reduction in power output caused by the shunting of the magnetic field. Nonmetallic mounting surfaces or plates may be used, but brass, aluminum, or other nonmagnetic metals are preferable because of better heat transfer and motor cooling.

Environmental conditions affect requirements of motor winding, material, and protective coatings. A typical standard shaded-pole motor has class A insulation, adequate for a winding temperature of 105 C. Because this limit is the sum of temperature rise and ambient temperature, temperature rise for rated input should be added to an elevated ambient to determine whether or not the total exceeds maximum allowable. For applications in which total temperature exceeds 105 C, the motors require class B insulation and special high-temperature lubricants. An example is a motor used to drive an electric-oven rotisserie.

For operation under normal humidity conditions, a stainless-steel shaft is the only precaution required, because motor laminations are normally treated or plated to provide protection against corrosion. Where high humidity or where fungus requirements apply, such as in military equipment, the motors can be vacuum impregnated and the rotors plated. In many cases, it may be economical or necessary to mount the motor in an oil-filled enclosure to provide protection against dust and harmful atmosphere.

Motor noise is occasionally a problem. The most common causes of motor noise are: end play of the rotor shaft and excessive bearing clearance. Reduction of this noise can be accomplished only by closer tolerances by the motor manufacturer. While this is generally feasible, motor cost is increased. Where a gear train is used, gear-tooth noise may be objectionable. With a gearhead motor, nonmetallic gears should be used in the high-speed steps.

Bearings supplied with the majority of shaded-pole motors are sleeve type, usually prelubricated sintered bronze. For very low bearing drag or low-temperature operation, it may be necessary to specify ball bearings; however, they increase cost.

MOTOR BRAKING

Effective braking of shaded-pole motors may be obtained mechanically or electrically. Unidirectional motors may be braked mechanically by utilizing the type of mechanical brake shown in Fig. 7(A). Here, magnetic forces which tend to center the rotor axially, disengage the brake when the motor is energized. When motor power is disconnected, the spring forces the end of the rotor against the cork washer.

Electrical braking may be obtained by passing direct current through the field coil of unidirectional motors or the shading coils of reversible motors. Excessive heating of the motor because of the d-c, can be avoided by charging or discharging a capacitor through the motor windings whenever the driving voltage is removed, so that the d-c flows only momentarily. This requires an electrolytic capacitor, a double-pole double-throw switch, and a dry-type metallic rectifier to supply the d-c Fig. 7(B). The capacitor is usually 50 to 100

Table II—Variation in Duty Cycle and Power Output of a Typical 115-v, 60-cycle Two-pole, Shaded-pole Motor for Three Different Windings

Motor Winding	Duty Cycle, min.			No Load		Stalled		Full Load			
	Without Fan		With Fan	Watts	Speed, rpm	Watts	Torque, lb-in.	Watts	Torque, lb-in.	Hp x 10^{-3}	Speed, rpm
	On	Off									
A	Cont.	..	Cont.	15	3550	24	0.08	21	0.17	8	2900
B	15	30		22		35	0.13	30	0.25	12	
C	10	35		31		51	0.18	45	0.33	15	

microfarad and is charged by the nominal 115v or 230v line voltage supplying the motor; for these values, the motor stops in 4 to 8 rpm. If instant stopping is desired, the capacitor may have to be as large as 500 microfarad.

CLUTCH OPERATION

Where the motor must be disconnected from the load shaft when deenergized, this can be accomplished by specifying more than normal end play of the rotor shaft and utilizing the available magnetic forces to move the rotor longitudinally and engage a clutch when the motor is energized, Fig. 7(C). Typical end play is $\frac{1}{8}$ in. and thrust is approximately 6 oz.

CONNECTIONS

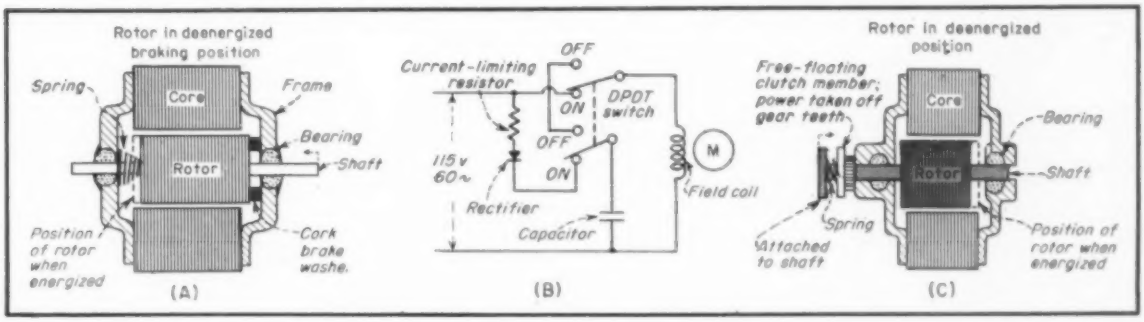
Shaded-pole motors are available with either solder terminals or with lead wires connected and taped to the field coil or coils. If Underwriter's Laboratory listing of the finished equipment is required, the method of electrical connections is important. Because load characteristics and environment of an application have a substantial effect on motor performance, the motors themselves cannot be U.L. approved. The complete device must be submitted if such approval is desired.

ENCLOSURES AND HOUSINGS

For many small motor applications such as pumps, fans, or small tools, use of an open motor mounting is not practical. Housings may be either stamped or die-cast, with the aluminum stamped housing being more economical. The die-cast housing may be assembled with a perforated spacing strip between the front and rear halves, but it can also be made almost dust-proof by covering the ventilating openings in the castings and substituting a solid strip for the perforated spacer. Both types of housings are adequately ventilated for most purposes, but when used with high input motors in other than fan applications, a cooling fan may be added to increase operating efficiency.

EDITOR'S NOTE: Because low power factor of larger shaded-pole motors causes high current drain for a given hp rating, this added current must be revaluated in combination with other motors used in a given equipment. "Motors for Direct-Connected Fans," May 1956 page 195, presents a method for determining combined motor currents of shaded-pole and other fractional-hp motors used in the same application, and for selecting best motor based on power-factor limitations. In "Applying Single-Phase Capacitor-Start Motors," October 1956 page 196, the effect of power supply, hp rating, duty cycle, and current limitations on choice of fractional and small integral-hp single-phase motors is described.

Fig. 7—Methods of braking and clutching. **(A)** Here, the spring-engaged and magnetically released brake is an integral part of unidirectional motor. When motor is deenergized, spring moves rotor axially against braking surface of a cork washer cemented to frame plate. When motor is energized, magnetic forces pull rotor into alignment with core and away from cork. **(B)** Electrical braking is achieved by passing momentary d-c current from capacitor through winding when line switch is thrown OFF. Size of capacitor varies from 50 to 500 microfarad. **(C)** Method of disconnecting motor from load when motor is deenergized. Rotor end play is provided in this type motor so that the rotor can move axially to engage or disengage the load. When the motor is energized, the magnetic pull on the rotor draws it into the stator and engages the clutch. When the motor is deenergized, the spring pushes the rotor sideways, disengaging the clutch.



20 Tamper-proof

FEDERICO STRASSER *Santiago de Chile*

Ways to prevent or indicate unauthorized removal of fasteners in vending machines, instruments, radios, TV sets and other units. Included are positively retained fasteners to prevent loss where retrieval would be difficult.

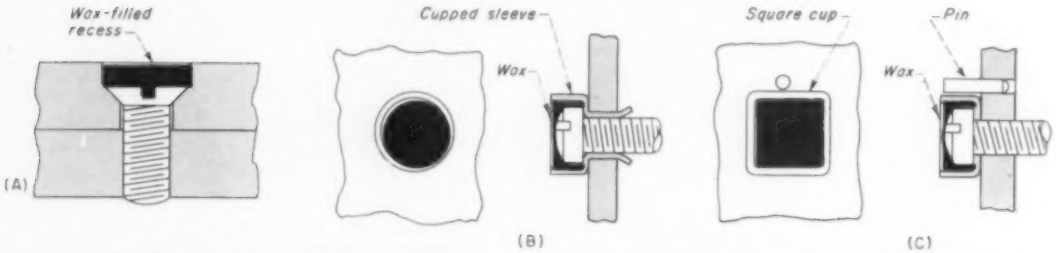


Fig. 1—(A) Wax or other suitable material fills recess above screw. Wax flush with plate hides screw position if surface is painted. (B) Cupped sleeve riveted in screw hole provides cavity for wax when plate is too thin for recessing. (C) Pin prevents rotation of square cup which would allow screw to be removed without disturbing wax.

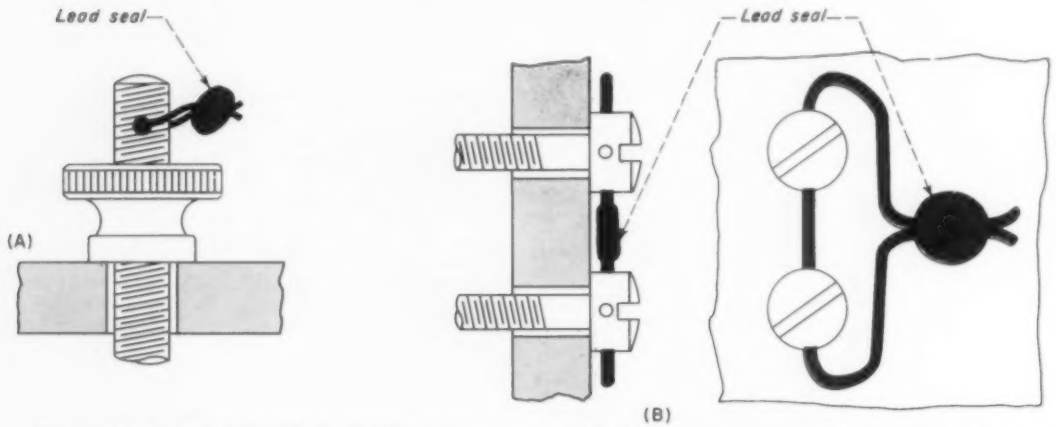


Fig. 2—(A) Lead seal crimped over twisted ends of wire passing through screw allows only limited slackening of nut. (B) Two or more screws strung through heads with wire are protected against unauthorized removal by only one seal. Code or other signet can be embossed on seals during crimping.

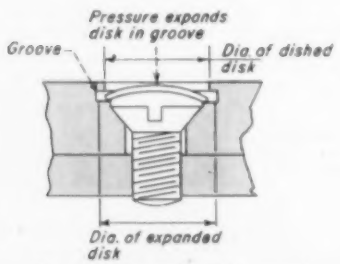


Fig. 3—Sheet-metal disk pressed into groove can only be removed with difficulty and discourages tampering.

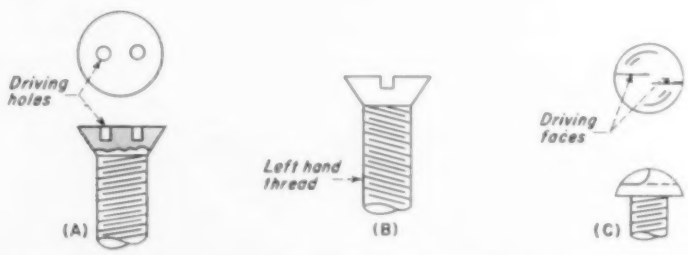
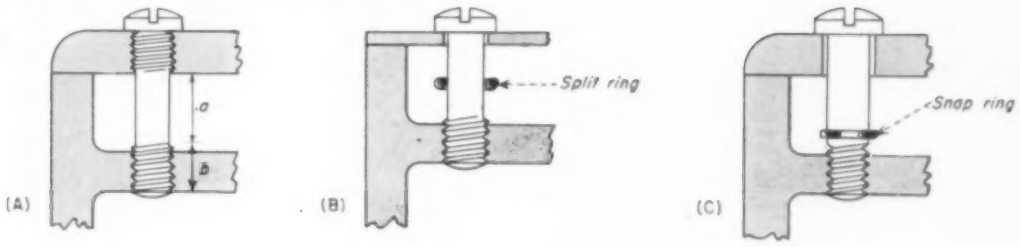


Fig. 4—(A) Spanner-head screws are available in all standard heads and sizes from U.S. manufacturers. Special driver is required for each screw size except ¼-in. dia and above. (B) Left-hand screw thread is sometimes sufficient to prevent unauthorized loosening, or (C) special head lets screw be driven but not unscrewed.

Fasteners

DESIGN ROUNDUP...

POSITIVELY RETAINED FASTENERS



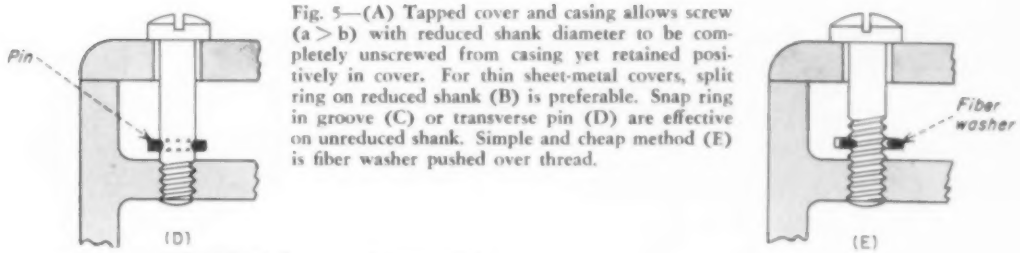


Fig. 5—(A) Tapped cover and casing allows screw ($a > b$) with reduced shank diameter to be completely unscrewed from casing yet retained positively in cover. For thin sheet-metal covers, split ring on reduced shank (B) is preferable. Snap ring in groove (C) or transverse pin (D) are effective on unreduced shank. Simple and cheap method (E) is fiber washer pushed over thread.

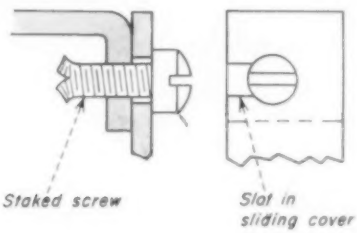
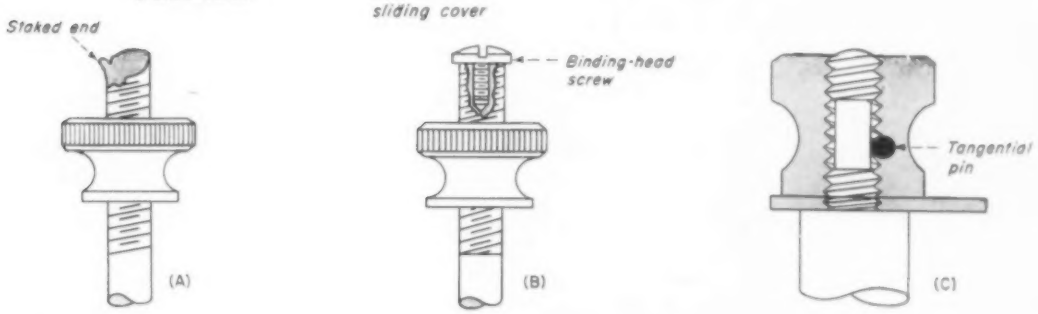


Fig. 6—Open-ended slot in sliding cover allows screw end to be staked or burred so screw cannot be removed, once assembled.



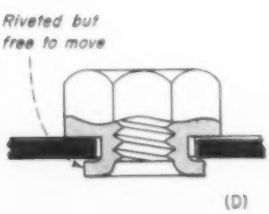
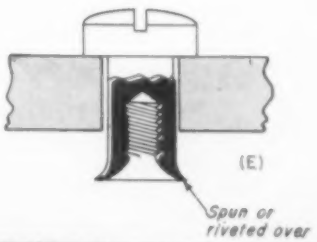


Fig. 7—(A) Nut is retained on screw by staking or similar method but, if removal of nut is occasionally necessary, coaxial binding-head screw (B) can be used. Where screw end must be flush with nut, pin through nut tangential to undercut screw (C) limits nut movement. Rotatable nut (D) or screw (E) should have sufficient lateral freedom to accommodate slight differences in location when two or more screws are used.



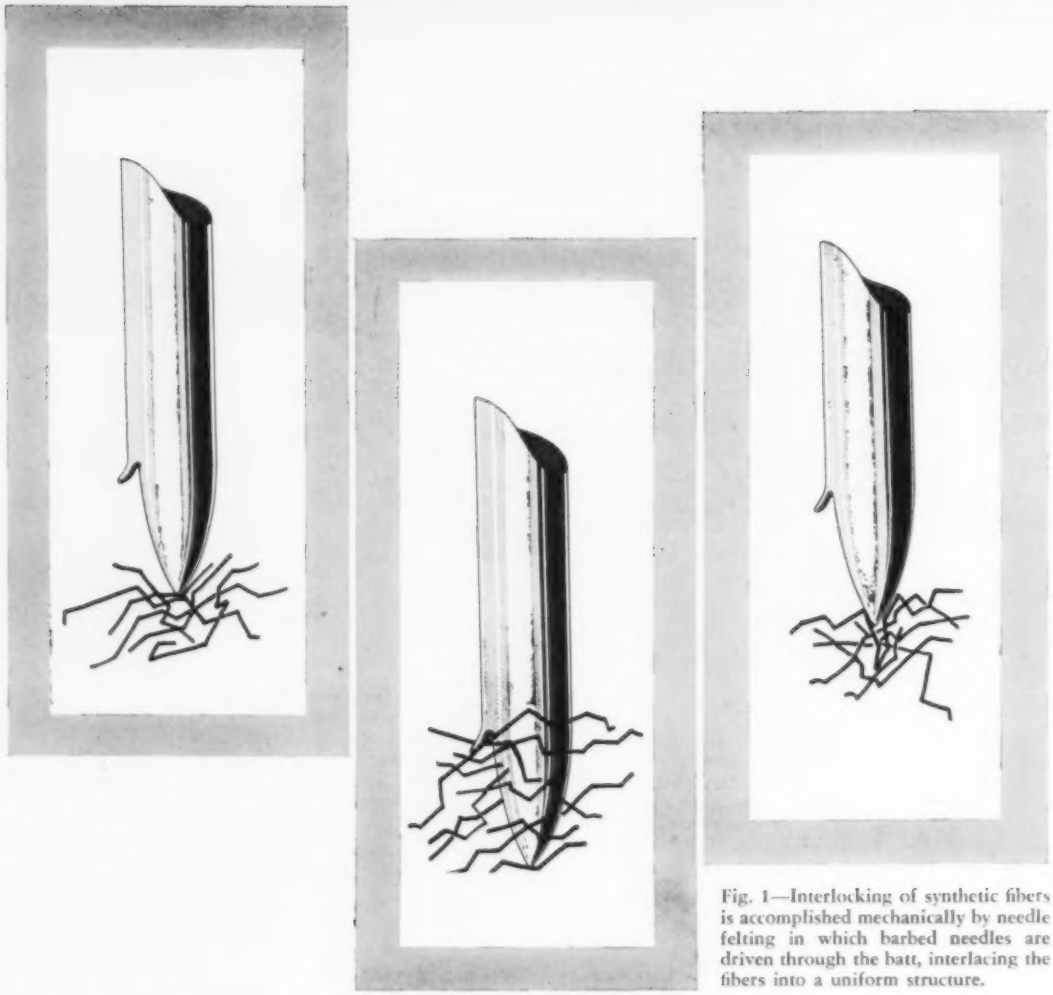


Fig. 1—Interlocking of synthetic fibers is accomplished mechanically by needle felting in which barbed needles are driven through the batt, interlacing the fibers into a uniform structure.

Four Types of—

Synthetic Fiber Felt

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have higher strength, better corrosion and heat resistance, less compression set than wool felts; changes in temperature and humidity have less effect, smoother surfaces can be obtained, and better filtering efficiency.

CONVENTIONAL wool felts shrink and lose strength after prolonged immersion in water at room temperature or shorter exposure to boiling water. In addition, the animal fibers from which they are made deteriorate when in contact with strong alkalis and some acids.

Synthetic felts are resistant to humidity and have the chemical inertness characteristic of the fibers from which they are are made: Dynel, Arnel, Orlon, Dacron, Acetate, Acrilan and Nylon. These characteristics of synthetic felts make them good for filters, seals, wicks and gaskets for service at temperatures above 200 F, or for prolonged or intermittent contact with water or steam or strong alkalis or oxidizing acids.

Major Types

The basic element of wool felt is a fiber which tends to curl into a spiral when mechanically agitated while subjected to heat and moisture. Synthetic fibers, however, must be interlocked mechanically.

Synthetic fiber felts start out as a continuous batt of chopped fibers fed to a machine which performs a needle felting operation, Fig. 1. This operation is

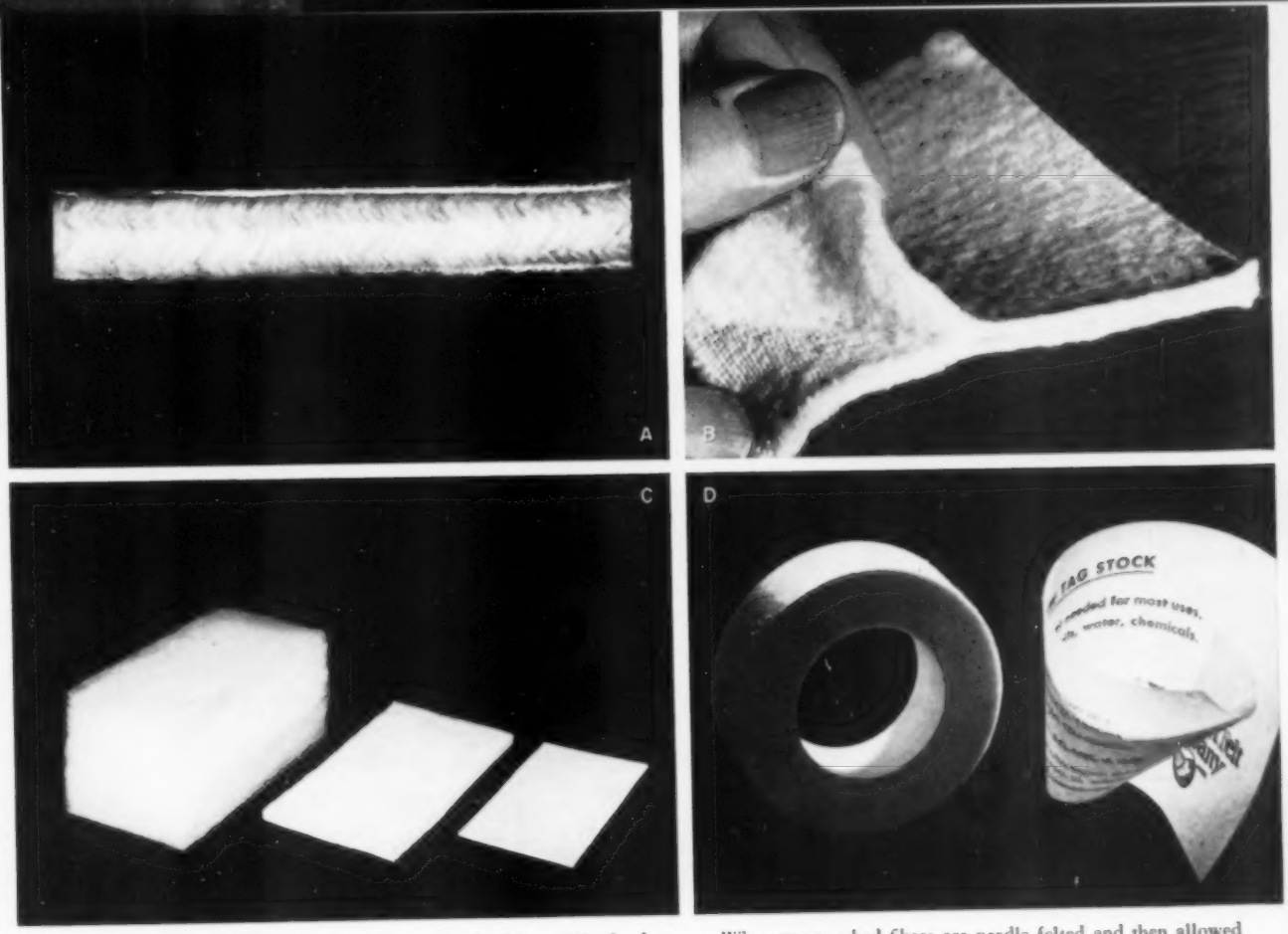


Fig. 2—Four major types of synthetic felts. (A) Section through felt produced by simple mechanical interlock shows orientation and uniform distribution of crimped fibers. (B) Woven insert, used as the base to which fibers are needle felted, imparts higher strength and lower elongation. (C) When prestretched fibers are needle felted and then allowed to shrink back, stronger, higher density felts are obtained. (D) Under heat and pressure, needle felted thermoplastic fibers weld together into solid shapes or paper-thin tough sheets widely used for liquid filtration.

common to all four types of synthetic fiber felts shown in Fig. 2.

Simple mechanical interlock. No other operation follows the needle felting of the batt. This felt has good breaking strength, but has large elongation in tension as fibers slide along each other.

Woven insert. When the batt is superimposed on a woven fabric and both are needle felted together, elongation under tension is less than for the simple mechanical interlock structure. Woven inserts give increased strength for the same weight or thickness. Because added strength is only along plane of cloth insert, these materials do not have the three-dimensional characteristics of conventional felts.

Shrinking. Fibers for batts are stretched well beyond the yield point before chopping. After mechanical interlock by needle felting the material is heated until the stretch relaxes. The fibers shrink back to unstretched size and length. Interlock produced by shrinking is tighter than can be produced mechanically.

Thermoplastic. After needle felting, fibers are fused or welded together by moderate pressure at a temperature in the softening range of the fiber. This produces a structure with high tensile strength in paper-thin tough sheets for filter applications.

Properties

Chemical properties of synthetic felts are the same as those of the fibers from which they are made. By selecting and mixing the fibers, it is possible to produce materials meeting a wide range of service conditions.

Mechanical properties of the fibers commonly used in synthetic felts are given in Table I. Tensile properties of a number of comparable synthetic fiber felts, Table II, show the effect of felting technique employed, while influence of fiber type on mechanical properties of felts is shown in Table III. Highest density obtainable by needle felting alone is 28%. Still higher densities require the use of prestretched fibers and heat shrinking.

Other properties of synthetic fiber felts important in many uses are: coefficient of friction, Table IV; deformation in compression and set, Table V; wicking rate and oil absorption, Table VI.

Filtration

The smooth surface of the fibers prevents entrapment of solid particles and consequent plugging, and facilitates the removal of solids accumulated on the face of the felt. Filter felts therefore are cleaned easily and have a high recovery of suspended solid.

Uniform distribution of fibers by controlled mechani-

Table I — Tensile Strength and Elongation of Synthetic Fibers Used in Felt

Type	Supplier	Tensile Strength psi	Elongation %
Dynel	Carbide & Carbon Chemicals Co.	40, –57,000	30–32
Arnel	Celanese Corp. of America	20, –26,000	22–28
Orlon	E. I. Du Pont de Nemours & Co.	28, –34,000	20–25
Dacron	E. I. Du Pont de Nemours & Co.	64, –71,000	36–42
Acetate		22, –28,000	23–30
Acrilan	Chemstrand Corp.	37, –40,000	36
Nylon 66		60, –66,000	37–40

Table II — Effect of Structure on Properties of Synthetic Felts

Structure	Fiber	Weight, oz/sq. yd.	Tensile Strength, psi	Elongation, %
Simple interlock	Dacron	24	1200	18
Woven insert	Dacron	24	1800	8
Prestretched and shrunk	Dacron	24	1400	14
Thermoplastic bonded	Dacron and Vinyon	20	5000	7

Table III — Physical Properties of Synthetic Fiber Felts. All Materials 24 oz/sq. yd.

Material	Size (dpf)	Thickness, in.	Width, in.	Density, %	Breaking Strength lb for 2 in. width	Elongation, % to rupture	Bursting Strength, psi, min.,	Air Permeability cfm/sq ft at 0.5 in. water
Dynel	3	0.125	72	25	120	80	500	30–40
Arnel	3	0.125	72	25	120	80	350	30–40
Orlon	3	0.125	72	25	220	60	500	10–20
Orlon (shrunk)	6	0.110	56	28	200	50	500	10–15
Dacron	3	0.125	72	25	350	90	500	20–30
Dacron (shrunk)	6.5	0.100	60	29	210	70	500	15–25
Acetate	5.5	0.125	72	25	80	45	450	60–70
Acrilan	3	0.125	72	25	200	60	500	20–30
Nylon 66	3	0.125	72	25	200	100	500	30–40

cal interlocking prevents voids and thin spots in the structure, and prevents "bleeding" or seepage of solids. At the same time, the close structure filters particles of very small size.

For air and gas filters synthetic fiber felts have the advantages of high breaking and bursting strength, uniform air permeability, good abrasion resistance and high efficiency in filtering out very small particles without becoming clogged.

Thermoplastic felts, widely used for liquid filtration, have excellent particle retention, freedom from plugging and resistance to fungus and corrosion. They do not shrink or ravel and serve as efficient gaskets preventing side leakage between elements of commercial filtering presses. These felts can be supplied in a smooth eggshell finish which assists in removing filtered material. Other advantages are dimensional stability even in boiling water and chemical solutions, and ease of cleaning —filters can be hosed in place to reduce down time.

Seals and Gaskets

For sealing, synthetic fiber felts offer a wide range of strength and resistance to specific chemical environment at temperatures up to 300 F, where synthetic fibers begin to break down.

When impregnated with dispersed tetrafluoroethylene, these felts become even more stable against attack by corrosive gases and liquids. They are not subject to lateral plastic flow. Temperature limits are not changed.

Wicks

Widest use of wicks is to lift oil in lubrication applications, hence rate of oil rise and oil absorption, Table VI, are important. Here synthetic fiber felts

Table IV — Coefficient of Friction of Synthetic Fiber Felts Against Glass

Material	Wet	Dry	Ratio
Dynel	0.225	0.210	1.072
Arnel	0.290	0.210	1.380
Orlon	0.170	0.185	0.920
Orlon (shrunk)	0.230	0.155	1.485
Dacron	0.180	0.160	1.124
Dacron (shrunk)	0.160	0.135	1.183
Acetate	0.330	1.180	1.830
Acrilan	0.220	0.190	1.158
Nylon 66	0.260	0.205	1.270

Table V — Deformation and Set of Synthetic Felts at 58.6 psi Load

Material	First Cycle		Second Cycle	
	Deformation, %	Set, %	Deformation, %	Set, %
Dynel	35.5	13.6	28.1	1.7
Arnel	41.6	10.8	36.8	2.2
Orlon	29.9	7.3	24.6	2.4
Orlon (shrunk)	37.6	9.9	23.6	3.1
Dacron	26.9	5.2	22.0	1.8
Dacron (shrunk)	25.9	5.0	15.8	0.0
Acetate	35.4	13.0	29.9	3.6
Acrilan	31.2	7.8	25.4	0.8
Nylon 66	26.8	8.0	22.8	0.8

Table VI—Wicking and Oil Absorption Properties. SAE No. 10 Lubricating Oil

Material	Wicking Distance, in.			Wick Rise Rate, in./min.			Oil Absorption, % by weight
	2 min	1 hr	16 hr	2 min	1 hr	16 hr	
Dynel	1.118	3.125	6.000	0.557	0.048	0.008	378
Arnel	0.937	2.000	5.062	0.468	0.046	0.008	328
Orlon	0.250	0.625	2.250	0.125	0.010	0.002	324
Orlon (shrunk)	0.750	3.250	6.250	0.300	0.043	0.006	348
Dacron	0.625	2.375	4.500	0.312	0.033	0.004	214
Dacron (shrunk)	0.630	3.120	4.900	0.314	0.042	0.005	322
Acetate	0.750	2.500	2.625	0.375	0.047	0.002	376
Acrilan	0.375	1.250	2.500	0.188	0.024	0.002	354
Nylon 66	0.500	1.625	2.000	0.250	0.027	0.002	384

are chosen for resistance to elevated temperatures, for dimensional stability, chemical inertness and immunity to pest and fungus attack.

Plastic Reinforcements

In the production of reinforced plastic parts, the resin and the reinforcement must fuse into a uniform dense structure. The ability of synthetic fibers to be wetted by resins promotes bonding.

Where the pressure-bag or the matched-die processes are used, simple mechanical interlock, woven insert, and shrunk synthetic fiber felts have good draping and tailoring properties needed in conforming to irregular shapes. As they do not ravel, the surface is unbroken by stray fibers. These felts are supplied in weights held to a maximum variation of 0.5 oz/sq yd and thickness variations of not more than 0.005 in.

For hand lay-up (contact molding) and vacuum bag process applications thermoplastic fiber felts have the advantage of toughness and thinness.

When used as overlays, these felts form a finished surface for painting and have a high resistance to ultraviolet radiation: an Orlon, for example, was not affected after 2900 hr exposure.

Dielectric Properties

Synthetic fiber felts have the same dielectric properties as the fibers from which they are made. For Dacron they are:

	Dry	Wet
Dielectric constant	0.30	0.32
Dissipation factor	0.012	0.012
Loss factor	0.036	0.040

(continued on next page)

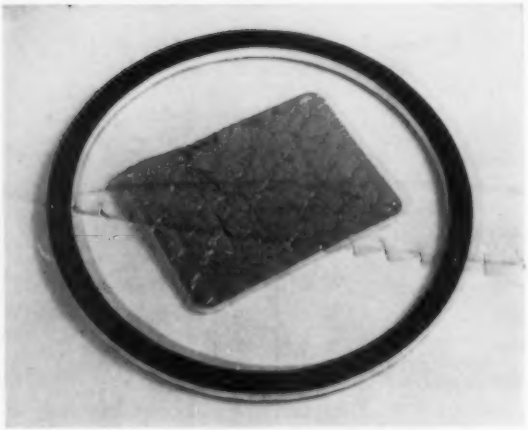


Fig. 3—Where a smooth, impervious surface is needed, plastic sheeting is bonded to one or both surfaces as in this gasket. Aluminum foil bonded to synthetic felts produces an easily cleaned high temperature barrier.

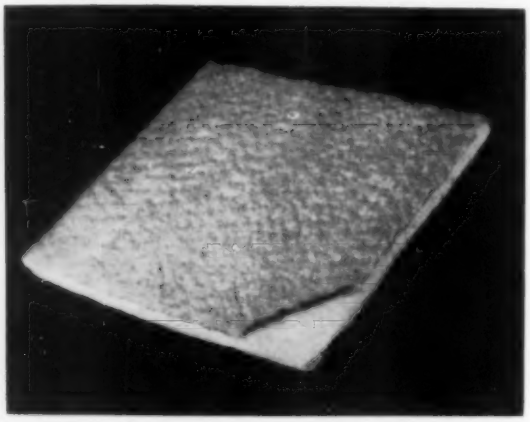


Fig. 4—Locking of metallic fibers to the surface of a synthetic fiber felt produces gasket and seal materials with both thermal resistance and electrical conductivity.

Definitions

Felt (ASTM D. 461-53)

Felt is a fabric built up by the interlocking of fibers by a suitable combination of mechanical work, chemical action, moisture, and heat. Felt may consist of one or more classes of fibers: wool, reprocessed wool, and reused wool, with or without admixture with animal, vegetable, and synthetic fibers.

Density

Ratio of weight of felt to the weight of an equal volume of fiber.

Breaking Strength

Average strength required to break a test specimen 2 in. wide.

Denier per filament (dpf)

Weight in grams of a single continuous strand of yarn 9000 meters long. For each material the dpf is proportional to the cross sectional area of the filament.

Bursting Strength

Force required to burst a standard specimen. Specimen is held in a circular clamp 1.750 in. dia; center of the specimen is pressed against a polished steel ball 1.000 in. dia. until specimen bursts. Travel line of clamp is normal to plane of specimen.

Special Applications

Where a smooth, fiber-free, scuff-proof, impervious surface is required, plastic sheets with the needed properties can be bonded to one or both surfaces. For a high temperature barrier, aluminum foil is bonded to a synthetic felt base, Fig. 3, and provides an easily cleaned surface.

Blending of metal fibers at the surface of mechanically interlocked felts, Fig. 4, provides gaskets and seals that combine resistance to heat with good electrical conductivity.

Expected Developments

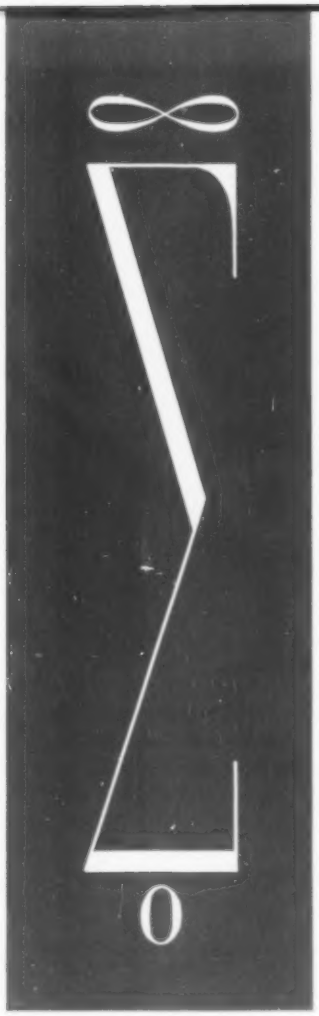
Direct fabrication of synthetic felts into engineering shapes is being developed: endless tubes have been made on an experimental basis.

Methods of bonding ceramic, asbestos and other special fibers to synthetic felts are being studied, and promise to raise the safe operating temperature of these materials beyond the present limit of 300 F. All metal fiber felts are being tested for special sanitary applications.

New techniques for interlocking fibers are being studied and promise to further enlarge the range of fabrication and application of synthetic felts. As new fibers with different properties become commercially available, tailor-made felts to meet specific engineering requirements will become a common occurrence.

EDITOR'S NOTE: Other articles on properties and uses of felting fibers include: "Fibrous Teflon," December 1954 page 190; Engineering applications of fluorocarbon fibers. "Special Treatments for Wool Felt," May 1954 page 194; Impregnations and proofings for resistance to water, flame, fungi and vermin; laminations and coatings.

Gasketing materials were treated in "Gasketed Joints," March 1957 page 183; "Gaskets for Raised Face Flanges," Mid-October 1956 page J14; "Eight Gaskets for High Static pressure," Mid-October 1954, page J30.



MATHEMATICAL TABLES . . .

a bibliography

CHARLES R. SEXTON, Walnut Creek, Calif.

An annotated list of tables of mathematical functions useful in the solution of engineering problems. References vary in complexity from multiplication, factor, interpolation and power tables through hyperbolic functions, Bessel functions, elliptic functions and many others.

Once the computer is familiar with the kinds of functions that have been tabulated and the form in which they appear, slide-rule and desk-calculator computations may often be bypassed with considerable increase in speed and accuracy. This bibliography is intended to show where a table of elementary functions can be found, its range of argument, decimals, etc., and to give a general idea of the tables contained in a given volume or set. Tables of higher functions are discussed in a more informal manner in the latter part of this article.

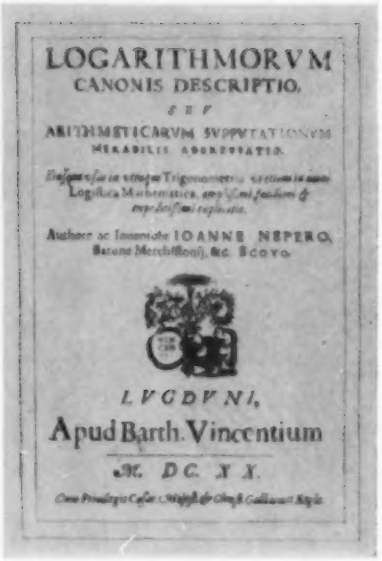
Because there are thousands of published tables, only a relatively small number can be considered here. Those that have been listed are either readily available (many in the $2 to $5 price range) or have some special merit which makes their inclusion mandatory. Tables listed as out of print can probably be borrowed from a large library. For information on many important tables not listed, the reader is referred to List G at the end of this article, which includes indexes, guides and periodical MTAC.

Tables mentioned are generally confined to numerical tables of mathematical functions. No attempt has been made to list tables of integrals, formulas, constants, etc., although these will be found in some of the volumes referred to here.

GENERAL COMMENTS, LISTS A-D

Information tabulated on these lists is for general guidance only. An attempt has been made to show the principal subdivisions of the argument over its range; however, where the interval fluctuates considerably, only a rough indication can be given. The expression 0(0.01)5(0.1)10 means that the argument proceeds in steps of 0.01 between zero and five, then by intervals of 0.1 from five to ten. Throughout lists A-D, a range of argument given as 10,000-100,000 or 1-49,999, for example, means that the argument proceeds in unit steps between the two limits.

Likewise, decimal places and significant figures (denoted by 5D and 6S,


LOGARITHMORVM
CANONIS DESCRIPTIO,
SEV
ARITHMETICARVM SVPPVTATIONVM
MIRABILIS ABBREVIATIO.
Author ac Inventore IOANNE NEPERO,
Barone Merchistonij, &c. SCOTO.
LVGDVNI,
Apud Barth. Vincentium
M. DC. XX.

Gr. 30

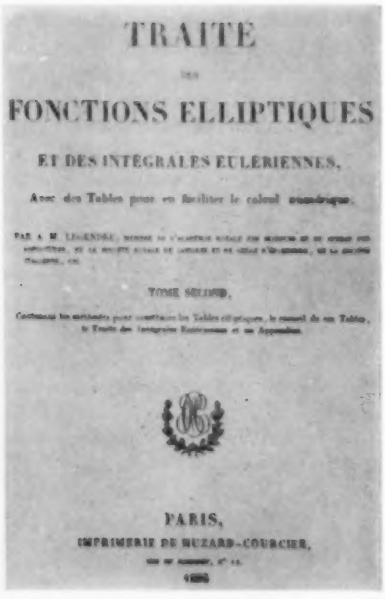
John Napier

(1550-1617) inventor of logarithms, published this table in 1620. Upper part of one page (30 degrees) is shown beside the front cover.

THREE GREAT TABLE MAKERS AND THEIR WORKS . . .

D. N. Lehmer

(1867-1938) member of a noted American family of table makers.


TRAITE
DES
FONCTIONS ELLIPTIQUES
ET DES INTÉGRALES EULÉRIENNES,
Avec des Tables pour en faciliter le calcul numérique.
TOME SECOND.
PARIS,
IMPRIMERIE DE HUZARD-COURCIER.

A. M. Legendre

(1752-1833) and title page of his famous work on elliptical functions.

for example) are those tabled generally, and must not be construed as applying to every part of the table. The symbol Δ appearing in the column *Provision for Interpolation* means that some type of first difference is furnished. If differences of higher order than the first are given, this is so indicated by a footnote.

P.P. means the familiar "proportional parts" often found in log tables. This symbol means that proportional parts appear on the various pages of the particular table under review or immediately adjacent to it. If a general table of proportional parts is elsewhere in the volume (such as in Chambers's Tables), but not on the pages of the particular function being discussed, the symbol *PP* is not shown. The letters *FV* denote the less widely-known "first variations" (interval times first derivative used in interpolation).

To give general idea of the contents of a given volume, a reference is made to other lists in which the same volume is mentioned. Because of the size of List D, if tables of the same volume or pair of volumes appear elsewhere in that list, this is so indicated.

In Lists A-G and elsewhere the reference numbers to publications of the AMS, CUP, and MT series are given exactly as shown in National Bureau of Standards List of Publications LP17 (revised) of July 1, 1956. A copy of this list may be secured free of charge by writing the National Bureau of Standards, Washington 25, D. C. Prices and directions for purchase of all AMS, MT, and CUP series publications in print are given.

ABBREVIATIONS

AMS—Applied Mathematics Series, Applied Mathematics Division, National Bureau of Standards, Washington 25, D. C. (See CUP and MT series, also)

BA—British Association for Advancement of Science Mathematical Tables (now Royal Society), Cambridge University Press, 32 E. 57th St., N.Y. 22, N.Y.

CUP—Columbia University Press Series. This series is fully described in National Bureau of Standards List of Publications, LP-17 (Revised) of July 1, 1956, but purchases should be made from Columbia University Press, Morningside Heights, N.Y. 27, N.Y. FMR calls these publications *New York WPA*.

FMR—Fletcher, Miller and Rosenhead's *Index* (see list G).

HUCL—Annals of the Computation Laboratory of Harvard University, 44 Francis St., Cambridge, Mass.

MT—Mathematical Tables Project. These publications are fully described in National Bureau of Standards List of Publications LP17 (Revised) of July 1, 1956. This series is also denoted *New York WPA* in FMR.

MTAC—Quarterly periodical *Mathematical Tables and Other Aids to Computation* (first published in 1943), National Research Council, National Academy of Sciences, 2101 Constitution Ave., Washington, D. C.

TC—*Tracts for Computers Series*, Cambridge University Press, 32 E. 57th St., N.Y. 22, N.Y.

Latest printing of each publication is usually identified either by giving a date, or statement such as *3rd revised edition*. Unless *out of print* appears after the title, it may be assumed that the work is available for purchase. (The expression *Reissued* as AMS-26 is to be interpreted

List A—MULTIPLICATION, DIVISION, AND FACTOR TABLES

Author or Maker	Abbreviated Title	Publisher or U.S. Agent	Gives Products To	Gives Quotients To	Factors Numbers To (a)	Other Tables in Volume
BA-Vol. 5	Factor Table (1935)	Cambridge University Press 32 E. 57th St., N.Y. 22, N.Y.	.....	.....	100,000	Reciprocals of prime numbers 11 to 9973
Brown & Sharpe Mfg. Co.	Formulas in Gearing (1954)	Out of Print	.....	.....	100,000(h)	Gear ratios, their decimal equivalent and logarithms; special gear tables; trig. functions.
Crelle, A. L.	Rechentafeln (1954)	Walter de Gruyter & Co. Genthiner Strasse 13 Berlin, Germany W-35	999 x 999	.....	.....	Squares and cubes of integers 1 to 999
Comrie, L. J.	Chambers's Six-Figure Tables Vol. 2, (1949)	D. Van Nostrand 120 Alexander St., Princeton, N.J.	.....	.....	3,400	See lists B, C, D.
Cotsworth, M. B.	Direct Calculator (small size) (1937)	Scientific Computing Service 23 Bedford Square, London, W.C. 1	999 x 999	.....	.....	Logarithms, square and cube roots, cubes, reciprocals 2 to 999, compound interest tables.
Holzinger, K. J.	Statistical Tables for Students (1931)	Univ. of Chicago Press 5750 Ellis Ave., Chicago, Ill.	99 x 100	100/99(b)	.....	Square and square roots 1 to 1050 4 place logarithms 100 to 999, miscellaneous statistical and special tables
Kavan, G.	Factor Table English (1937) & Czech editions	Out of Print	.....	.....	256,000	.....
Lehmer, D. N.	Factor Table (1909) Carnegie Inst. Publ. #105	Stechert-Hafner, Inc. 31 E. 10th St., N.Y. 3, N.Y.(c)	.....	.....	10,017,000(d)	.....
Peters, J.	New Calculating Tables (1924)	Same as Crelle, A. L. above	99 x 9999	.....	.....	.....
Page, R. M.	14,000 Gear Ratios (3rd printing)(e)	Industrial Press 148 Lafayette St., N.Y. 13, N.Y.	.....	120/120(f)	14,400(g)	Special tables for gear computations
Zimmermann, H.	Rechentafeln (unbound)(i) (1948)	I. R. Maxwell & Co., Ltd. 122 E. 55th St., N.Y. 22, N.Y.	100 x 999	.....	999(j)	For range 0(0.1)99.9 gives squares cubes, and square and cube roots; also reciprocals and logarithms.

Notes:

(a) Unless otherwise noted, all numbers, both odd and even, are factored in the table up to the limit indicated.

(b) For quotient N/D, N ranges from 1 to 100 and D ranges from 2 to 99. Results are given to 4 significant figures.

(c) Recently reprinted by Stechert-Hafner. 35 mm microfilm also available from Carnegie Institution, Washington 25, D. C.

(d) Gives lowest prime factor of every number not divisible by 2, 3, 5, or 7, to limit shown.

(e) Second and third printing of this volume is probably nearly error-free as a result of recalculations. First printing was in 1942.

(f) For quotient N/D, N ranges from 1 to 120 and D from 2 to 120. Results are given to 9 or more decimal places. Seven-place logarithms of these quotients are given in Section 2 of the volume.

(g) The special factor table does not give factors of a number such as $N = 9921 (3 \times 307)$; i.e. where one of the prime factors is greater than 120.

(h) One table gives factors of all numbers to 10,200; a second table gives the lowest prime factor of numbers not divisible by 2 or 5 in the range 10,000-100,000.

(i) Many of the older editions were bound volumes, and can sometimes be located by large dealers.

(j) Factors of odd numbers only.

List B—TABLES OF POWERS, ROOTS, RECIPROCALS, FACTORIALS

6D—6 decimal places 6S—6 significant figures

Author or Maker	Abbreviated Title	Publisher or U.S. Agent	Powers (m)	Roots (a)(m)	Reciprocals (a)	Factorials	Other Lists
Allen, E. S.	Six-Place Tables (1947)	McGraw-Hill Book Co. 330 W. 42 St., N.Y. 36, N.Y.	2nd, 3rd: 1–1000 5th: 0.1 (var.) 40	2nd, 3rd: 1–1000	1–1000	(b)	C, D
BA-Vol. 9	Table of Powers (1950)	Cambridge Univ. Press 32 E. 57th St., N.Y. 22, N.Y.	2nd to 12th: 1–1099 13th to 20th: 1–299 21st to 50th: 1–120	.....	.....	.....	.....
Barlow, P. Comrie, L. J.	Barlow's Tables (1954)	Tudor Publishing Co. Order from Harlem Book Co. 221 4 Ave., N.Y. 3, N.Y.	2nd, 3rd: 1–12,500 4th: 1–1000, 5th to 10th: 1–100 11th to 20th: 1–10	2nd, 3rd: 1–12,500 (c)	1–12,500 (c)	1–100	.....
Burroughs	Table of Reciprocals No. C-2029 (1955)	Burroughs Adding Machine Co. Detroit 32, Mich.	.....	.....	1–10,000	.....	.....
Clements, G. R. Wilson, L.T.	Manual of Mathematics and Mechanics (1947)	McGraw-Hill Book Co. 330 W. 42 St., N.Y. 36, N.Y.	2nd, 3rd: 1–999 (k)	2nd, 3rd: 1–1000 (k)	1–1000	(b)	C, D
Comrie, L. J.	Chambers's Six-Figure Tables (1949) Vol. 2	D. Van Nostrand Co. 120 Alexander St., Princeton, N.J.	2nd, 3rd: 1–3,400 4th: 1–1000 5th: 1–100 (d)	2nd, 3rd: 1–1000 4th, 5th: 1–100 (d)	1–1000 (d)	1–1000 (d)	A, C, D
Cotsworth, M. B.	Table of Reciprocals (1902)	Out of print.	.....	.....	1–100,000 (e)	.....	.....
CUP-1	Table of Reciprocals (1943)	Out of print.	.....	.....	100,000–200,009 (f)	.....	.....
CUP-7	Tables of Fractional Powers (1946)	Out of print.	(g)	(g)	.....	.....	.....
Fowle, F. E.	Physical Tables, Publ. No. 3171 (8th rev. ed.)	Smithsonian Institution Washington 25, D.C.	2nd, 3rd: 10–999	2nd: 10–999	10–999	1–20 (h)	C, D
Jahnke, E. Emde, F.	Tables of Functions (Elementary) 4th ed. (n)	Dover Publications 920 Broadway, N.Y. 10, N.Y.	(l)	(l)	.....	.....	C
MT-1	Table of First Ten Powers (1939)	Out of print.	2nd to 10th: 1–1000	.....	.....	.....	.....
Oakes, W. H.	Table of Reciprocals (1865)	Out of print.	.....	.....	10,000–100,000 (f)	.....	.....
War Dept., Corps of Engineers	Hydraulic Tables (1944) Publ. #W7.2; H 99/2/944	Supt. of Documents Washington 25, D.C.	(i)	(i)	.....	.....	.....
Zimmermann, L.	Vollstandige Tafeln Der Quadrate (Table of Squares) (1946)	Out of print. Last ed. by J. W. Edwards, Ann Arbor, Mich.	2nd: 1–100,009 (j) 3rd: 1–999 4th to 9th 1–99	.....	.....	.....	.....

Notes:
(a) Roots and reciprocals are carried out to decimal places or significant figures approximately as follows: Allen, Root-4D, Reciprocals-9D; Barlow-Comrie, Roots-6-7D, Reciprocals-7S; Burroughs, 7S; Clements & Wilson, Roots-4D, Reciprocals-6S; Comrie (Chambers's Tables), Roots-6D, Reciprocals-6S; Cotsworth, 7S; CUP-1, 7S; Fowle, Sq. Root-4D, Reciprocal-6S; Oakes, 7S.
(b) Has $\log n!$ ($n = 1$-100)
(c) Also has $(10n)^{1/3}$ ($n = 1000$-12,500) and $1/(n)^{1/2}$ ($n = 2$-1000); has first differences of roots and reciprocals for $n = 1000$-12,500.
(d) For $n = 1$-100, also has $1/n^2$; for range $n = 100$-1000 has $(10n)^{1/2}$, $1/(10n)^{1/2}$, $(10n)^{1/3}$, $(100n)^{1/3}$. Also has $\log n!$ and $1/(n)^{1/2}$ for $n = 1$-1000. All values mentioned in this note are generally 6S or 6D.
(e) Has proportional parts of certain differences for interpolation.
(f) Has differences and proportional parts for interpolation.
(g) Has tables of fractional powers too diverse to fully describe here. Has 15D or 15S values, described in part as follows: A^x, $A = 2(1)9$, $x = 0(.001).01(.01)0.99$; $A = 10$, $x = 0(.001)1$, thus a table of antilogarithms; $A = \pi$ and $x = 0(.001)1$, and $\pm x = 1/4, 1/3, 1/2, 2/3, 3/4, 1(1)12$; $A = 0(.01)0.99$ with various decimal values of x between .001 and 0.99; also X^a for $X = 0(.01)10$, $\pm a = 1/4, 1/3, 1/2, 2/3, 3/4$. Has 7D values of X^a for decimal values of X between 0 and 0.99, with values of $a = 0(.01)0.99$. Has an extensive bibliography.
(h) Also has $\log n!$ ($n = 1$-100), and $1/n!$ ($n = 1$-20).
(i) For range 0(.01)30(0.1)99.9, gives 2/3, 5/3, 4/3, 2/3, and 3/5 powers; for 3/5 power has additional range of 100(1)999. Tabled values generally are given to 4 significant figures.
(j) Has differences for interpolation.
(k) Has $1/(n)^{1/2}$ for $n = 1$-100.
(l) Has second to fifteenth powers of x ($x = 0.50$(various)5.00); also small table of $x^{0.60n}$, for $n = 1(1)20$ and $x = 0.5$(various)10.0; 4-5S.
(m) For unusual fractional powers, see the following listed below; CUP-7; Jahnke & Emde; War Dept.-USCE-Hydraulic Tables.
(n) Elementary functions incorporated with higher functions described in latter part of this article.

as meaning that AMS-26 is available for purchase at present).

This rule applies generally, except for certain articles originally contributed to journals, etc., mentioned in Lists E and F. Reprints of some are available for purchase or free distribution; others are out of print.

MULTIPLICATION TABLES—LIST A

Use of multiplication tables will often prove less fatiguing than a slide rule, and the work may take less time. Further, exact products are important for computations in dollars and cents.

Crelle and Cotsworth are the most useful of the tables listed because of their range. Peters and H. Zimmermann have less utility for general purpose, although for products of certain kinds they may be more convenient.

TABLES OF QUOTIENTS—LIST A

Tables of this kind are relatively few in number, and do not go much above 100 for numerator and denominator. Several books on gearing have such values, but some are not convenient for rapidly ascertaining say, 87 divided by 23, because the arrangement is in order of the decimal equivalent.

Where an extensive series of simple quotients is required, Page is invaluable, giving results to 9 or more decimal places. Holzinger is a small convenient volume, but only gives quotients to 4 significant figures.

FACTOR TABLES—LIST A

Although not used by engineers as frequently as some others, a factor table is very convenient at times. There is no general method known for the rapid factorization of any number. Hence, attempting to work out the factors of even a single number of modest magnitude may cause an exasperating delay, not to mention the prospect of trying to factor a prime number.

Within their range, Kavan or the British Association

volumes are the most useful where many larger numbers, both odd and even, must be factored rapidly. In order to avoid undue bulkiness, Lehmer omits numbers which are multiples of 2, 3, 5, and 7, and only gives the lowest prime factor of each of the numbers considered.

Other factor tables and lists of prime numbers are mentioned in Fletcher, Miller and Rosenhead, the *Bibliography* of Davis, and in D. H. Lehmer's *Guide to Tables in the Theory of Numbers* (noted in List G).

TABLES OF POWERS, ROOTS, RECIPROCALS, ETC.—LIST B

List B indicates the classes of powers, roots, etc., to be found in the volumes described. For example, British Association Mathematical Tables-Vol. 9 gives all powers up to and including the 12th, for all numbers up to and including 1099. For the range of numbers 1,299 the 13th-20th powers are given. The 21st to 50th powers are given for the numbers 1-120. Likewise, Barlow's Tables gives squares, cubes, square roots, cube roots, and recipro-

List C—TABLES OF COMMON AND NATURAL LOGARITHMS AND ANTILOGARITHMS; e^{-x}

Δ—some type of first difference
PP—proportional parts
FV—first variation
6D—6 decimal places
6S—6 significant figures

Author or Maker	Abbreviated Title	Publisher	Base 10	Base e	Other Lists
Allen, E. S.	Six-Place Tables (1947)	McGraw-Hill Book Co. 330 W. 42 St., N.Y. 36, N.Y.	Log (1000–10,000), 6D; PP; Δ	Ln .01(.001)9.999, 6D; e exp x and e exp −x range 0(.001)1, 1(various)6. 6D (a);	B, D
AMS-27	Tables of 10^x (antilogarithms) (1953)	Supt. of Documents Washington 25, D.C.	Log $-1$0(.0000011, 10D; (b) Radix Table, 15D; (c)	.....	.....
Becker, G. F. Van Orstrand, C. E.	Hyperbolic Functions Publ. No. 1871, 6th reprint	Smithsonian Institution Washington 25, D.C.	.....	Ln 1(1)1000, 1000(primes) 10,000, 5D; FV; e exp x and e exp −x range 0(.001)3(.01)15; 1(1)100, 7-9S; (d)	D
Bruhns, C.	New Manual of Logarithms (1941)	D. Van Nostrand Co. 120 Alexander St., Princeton, N.J.	Log (1–100,000), 7D; PP;	.....	D
Clements, G. R. Wilson, L. T.	Manual of Mathematics and Mechanics (1947)	McGraw-Hill Book Co. 330 W. 42 St., N.Y. 36, N.Y.	Log (100–1899), 4D;	Ln 1(.01)9.99, 1(1)1000, 4D; e exp x and e exp −x range 0(.01)3.50(.05)6.00(0.1)10, 4-5S; (e)	B, D
Comrie, L. J.	Chambers's Six-Figure Tables Vols. 1–2 (1949)	D. Van Nostrand Co. 120 Alexander St., Princeton, N.J.	Log (10,000–100,000), 6D; PP; Log -1 0(.0001)1, 6S, PP;	Ln 1(.001)10, 6D; Δ; e exp x range 0(.001)6(var)100 e exp −x range 0(.001)3(var)14.5 (n)	A, B, D
Dwight, H. B.	Mathematical Tables (1944)	Out of print.	Log (100–1000), 4D; Δ;	Ln 1(.001)3(.01)10, 4D; Δ; e exp x and e exp −x range 0(.001)5, 4-5S;	D
Flügge, W.	Four-Place Tables of Transcendental Functions (1954)	McGraw-Hill Book Co. 330 W. 42 St., N.Y. 36, N.Y.	.....	Ln 1(.01)10.09, 4S; e exp x and e exp −x range 0(.01)10.09, 4S	D
Fowle, F. E.	Physical Tables (8th rev. ed.) Publ. No. 3171	Smithsonian Institution Washington 25, D.C.	Log (100–999), 4D, PP Log (1000–1999), 4D; Log -1 0(.001).999, 4S; PP; Log -1 0.9(.0001)1, 4S;	e exp x and e exp −x range 0(.01)5.5(0.1)10, 5S, 6D; (f)	B, D
Institut Geographique National	Table des Logarithmes (1944)	Inst. Geog. National 107 Rue la Boetie, Paris VIIIe, France	Log (1–120,000), 8D; PP;	.....	.....
Jahnke, E. Emde, F.	Tables of Functions (Elementary) 4th ed. (g)	Dover Publications 920 Broadway N.Y. 10, N.Y.	.....	Ln 1(.01)9.99, 4D; Δ; e exp x range 0(.01)0.99, 4-5S; e exp −x range 0(.01)6.99, 4-5S;	B
MT-2	Tables of e^x (1947)	Out of print. (h)	.....	e exp x range 0(.0001)2.5(.001)5(.01)10, 1(1)100 e exp −x range 0(.0001)2.5, 1(1)100, 12-18D	.....
MT-7	Natural Logarithms Vol I (1941)	Out of print.	.....	Ln (1–49,999), 16D	.....
MT-9	Natural Logarithms Vol II (1941)	Out of print.	.....	Ln (50,000–99,999), 16D	.....
MT-10	Natural Logarithms Vol III (1941)	Out of print. (i)	.....	Ln 0(.0001)5, 16D	.....
MT-12	Natural Logarithms Vol IV (1941)	Out of print. (i)	.....	Ln 5(.0001)9.9999, 16D	.....
Peters, J.	Zehnstellige Logarithmentafel Band I (see List D for Band II) (1922)	Frederick Unger Publishing Co. 105 E. 24 St., N.Y. 10, N.Y. (o)	Log (1–100,000), 10D; Δ; (p)	(p)	D
Spenceley, G. W. & R.M. Epperson, E. R.	Log Tables to Base e and Base 10 (Publ. #4054) (1952)	Smithsonian Institution Washington 25, D.C.	Log (1–10,000), 23D; Radix Tables	Ln (1–10,000), 23D; Radix Tables	.....
Thompson, A. J.	Logarithmetica Britannica	Cambridge University Press 32 E. 57 St., N.Y. 22, N.Y.	Log (10,000–100,000) 20D; (k) (l) (m)	.....	.....

Notes:
(a) Applicable to both e^x and e^{-x}.
(b) For last digit errors in Table 1 see MTAC, July 1954, p 164.
(c) Radix tables are self-interpolating, and are arranged for calculation of the antilogarithm of any number up to about 15 significant figures.
(d) Also has 7-place common logarithms of each value of e^x tabled ($x = 0$-15) and 10-place common logarithms ($x = 1$-100).
(e) Also has 4-place common logarithms of each value of e^x tabled.
(f) Has 5-place common logarithms of each value of e^x tabled. Also has values of e exp x^2 and e exp $-x^2$ and their 5-place common logarithms for $x = 0(.1)5$.
(g) Elementary functions are incorporated with tables of higher functions, described in latter part of this article.
(h) Reissued as AMS-14. The range of the table of e^{-x} was later extended by publication of AMS-46. The latter gives e^{-x} for $x = 2.5(.001)10$, 20D.
(i) Reissued as AMS-31.
(j) May be reissued in AMS. Has auxiliary table enabling the computation of the logarithm of any number to 24 places.
(k) Originally published in nine separate parts (in TC series) at intervals after 1924 (some parts still in print). Recently reissued in two-volume edition.
(l) Has second and fourth differences for interpolation by Everett formula.
(m) Has special antilogarithmic table in Part 9 (1924).
(n) Over a good part of range, first differences given for both e^x and e^{-x}.
(o) Recently reprinted in German edition (3 vol); also an English translation (3 vol).
(p) Special many-place tables of common and natural logarithms are in "Anhang" (Appendix).

List D-1—CIRCULAR FUNCTIONS

Δ—some type of first difference.
PP—proportional parts.
FV—first variation.
6D—6 decimal places.
6S—6 significant figures.
s—sine
c—cosine
t—tangent
ct—cotangent
sec—secant
csc—cosecant

Author or Maker	Abbreviated Title	Publisher	Natural Values	Logarithmic Value (Base 10)	Other Lists
Degrees and Decimals					
AMS-5	Sines and Cosines (1949)	Supt. of Documents Washington 25, D.C.	s, c; .01 deg; 15D; (aa)	.....	.....
AMS-40	Secants and Cosecants (1954)	Supt. of Documents Washington 25, D.C.	sec, csc; .01 deg; 9S;	.....	.....
Comrie, L. J.	Chambers's Six-Figure Tables Vol. 1–2 (1949)	D. Van Nostrand Co. 120 Alexander St., Princeton, N.J.	s, c, t, ct, sec, csc; .01 deg; 6D; 6S; Δ_2 (Vol. 2).	s, c, t, ct; .01 deg; 6D; Δ_2 (Vol. 1) (ab)	A, B, C, D
Dwight, H. B.	Mathematical Tables (1944)	Out of print	s, c, t, ct, sec, csc; .01 deg; 5D-5S; Δ_2	s, c, t, ct; .01 deg; 5D; Δ_2	C, D
Flügge, W.	Four-Place Tables of Transcendental Functions (1954)	McGraw-Hill Book Co. 330 W. 42 St., N.Y. 36, N.Y.	s, c, t, ct; 0.1 deg; 4D-4S;	.....	C, D
Peters, J.	Seven-Place Values (1942)	D. Van Nostrand Co. 120 Alexander St., Princeton, N.J.	s, c, t, ct; .001 deg; 7D-7S; PP;	.....	.....
Peters, J.	Zehnstellige Logarithmentafel Band II (1919)	Frederick Unger Publishing Co. 105 E. 24 St., N.Y. 10, N.Y. (ak)	.....	s, c, t, ct; .001 deg; mostly 10D; Δ_2	C
Radians					
Allen, E. S.	Six-Place Tables (1947)	McGraw-Hill Book Co. 330 W. 42 St., N.Y. 36, N.Y.	s, c, t, ct; 0(.01)3.20; 4D;	s, c, t; 0(.01)3.20; 4D	B, C, D
BA-Vol. I	Circular and Hyperbolic Functions (1951)	Cambridge Univ. Press 32 E. 57 St., N.Y. 22, N.Y.	s, c; 0(0.1)50, 15D; 0(.001)1.6, 11D;	.....	D
Becker, G. F. Van Orstrand, C. E.	Hyperbolic Functions (Publ. No. 1871—6th reprint)	Smithsonian Institution Washington 25, D.C.	s, c; 0(.0001)0.1(.001)1.6, 5D; FV; 0(0.1)10, 0(1)100, 10D; (ac)	same as natural values but all 5D	C, D
Clements, G. R. Wilson, L. T.	Manual of Mathematics and Mechanics (1947)	McGraw-Hill Book Co. 330 W. 42 St., N.Y. 36, N.Y.	s, c, t, ct, sec, csc; 0(various)10; 3-4S; (ai)	.....	B, C, D
Comrie, L. J.	Chambers's Six-Figure Tables Vol. 1–2 (1949)	D. Van Nostrand Co. 120 Alexander St., Princeton, N.J.	s, c, t, ct, sec, csc; 0(.001)1.6, 6D; 6S; Δ_2 (aj) (Vol. 2)	(ad)	A, B, C, D
CUP-3	Circular and Hyperbolic Tangents and Cotangents (1947)	Columbia University Press Morningside Heights, N.Y. 27, N.Y.	t, ct; 0(.0001)2, 8-10S, 0(.1) 10, 10D; (ae)	.....	D
Dwight, H. B.	Mathematical Tables (1944)	Out of print.	s, c; 0(.001)2, 4D; t; 0(.001)1.57, 4-5S; Δ_2	.....	C, D
Flügge, W.	Four-Place Tables of Transcendental Functions (1954)	McGraw-Hill Book Co. 330 W. 42 St., N.Y. 36, N.Y.	s, c, t; 0(.01)10.09, 4D-4S;	.....	C, D
Fowle, F. E.	Physical Tables (Publ. No. 3171—8th rev. ed.)	Smithsonian Institution Washington 25, D.C.	s, c, t, ct; 0(.01)1.6; 5D or 5S;	same as natural values, all 5D	B, C, D
MT-3	Circular and Hyperbolic Sines and Cosines (1949)	Out of print. (af)	s, c; 0(.0001)1.9999; 0(0.1)10; 9D	.....	D
MT-4	Sines and Cosines (1940)	Out of print. (ag)	s, c; 0(.001)25.2; 0(1)100; 8D; (ah)	.....	.....

Notes:
(aa) Has second differences and coefficients for interpolation by Everett formula.
(ab) See note (ad) below in "Radians" section. This table (VI—Vol 1) has the dual argument in degrees and decimals, and radians, as described there. Has 0.001 deg interval below five degrees for log sin and log tan.
(ac) For each value of radian argument, gives equivalent in sexagesimal measure to hundredths of seconds (range 0-1.6 rad) and to 10^{-7} seconds for radian arguments of 0(.1)10 and 0(1)100.
(ad) Basically, Table VI (Vol 1) has its argument in degrees and decimals (see note (ab) above in "Degrees and Decimals" section). However, a dual argument in radians is given to 6 decimal places (rounded off), which when combined with a table of proportional parts, gives the equivalent of a table with radian argument (interval .000175 rad).
(ae) Has some second differences and table of coefficients for interpolation by Everett and Gregory-Newton formulas.
(af) Reissued as AMS-36.
(ag) Reissued as AMS-43.
(ah) AMS-37 (not listed here) has a short table giving 8 decimal values of circular sines and cosines for radian arguments 100(1)1000.
(ai) Interval is generally .05 in lower portion of range, but drops to .02 in critical parts of argument; interval generally .10 in mid-portion of range, but likewise drops to .05 in parts; interval .50 from 6.50 to 10.
(aj) For radian argument 0(various)5,000 has sin and cos; for radian argument 0 to 0.1 has .0001 interval for ct and csc.
(ak) Recently reprinted in German edition (3 vol); also an English translation (3 vol).

cals of all numbers to 12,500, fourth powers of numbers from 1 to 1,000, and factorials of numbers from 1 to 100. For integers from 1 to 100, the 5th-10th powers are provided, the 11th to 20th powers of numbers from 1 to 10 are tabulated and other roots are given as detailed in the footnotes to List B.

Barlow's Tables is probably the volume needed by engineers who find themselves hampered by the low argument ranges of many of the more common tables of powers, roots and reciprocals. Allen is one of the most convenient of the shorter collections of tables in this classification, and can easily be fitted into a pocket or briefcase. Clements and Wilson has a good collection of formulas, curves, etc., in addition to the numerical tables shown in Lists B, C and D.

The two volumes of Chambers's *Six-Figure Mathematical Tables* are a fine example of the work of a great tablemaker. In 1954, a condensed version of these tables entitled *Chambers's Shorter Six-Figure Mathematical Tables* was issued. Details of the latter volume will not be given in this article, although it is an eminently suitable candidate for Lists A, B, C, D, and F.

L. Zimmermann is the largest table of squares ever published. The numerical tables in Fowle are a small part of a large collection of tables relating to various aspects of physics. The 9th revised edition (1954) eliminated the majority of the tables detailed on Lists B, C, and D, which had been in the 8th and prior editions for years.

Remaining volumes of List B are more specialized, several having higher ranges of powers and reciprocals. CUP-7 is a particularly comprehensive compendium of fractional powers. A table of certain fractional powers of primes contained in this volume is an aid to the calculation of values not given in the tables.

COMMON LOGARITHMS—LIST C

"Working tables" might be defined as those used in calculations where 4-8 place tables usually give sufficiently accurate results. Allen, Bruhns, Clements and Wilson, Chambers, and the Fowle are representative of this class. For those who like a foreign flavor and desire to get a table, the previous edition of which is known to be virtually error-free, the *Institut Geographique National* table is appropriate. This table has a companion volume giving trigonometric functions with argument in grades.

The *Anhang* at the back of Vol. I of Peters *Zehnstellige Logarithmentafel* (10-place recently reprinted) contains a diverse and notable collection of fundamental and many-place tables (same as Appendix-Vol I of new English translation). Although often it is perhaps somewhat difficult of access, engineers doing advanced or special mathematical work should examine the *Anhang*, or Appendix. When special information on logarithms or logarithms of functions is needed reference should be made to Fletcher, Miller and Rosenhead's *Index* described below and in List G.

Where unusual roots and powers of numbers are being calculated to many figures, ordinary working tables of logarithms may not give sufficiently accurate results. In this event, Thompson's magnificent 20-place tables may be used. This work is arranged for interpolation by Everett's formula. (Also see CUP-7 on List B).

The recently published 23-decimal *Smithsonian Logarithmic Tables* (Spenceley and Epperson) to the base e and base 10 are constructed for the employment of an easy factorizing method of interpolation. A good calculating machine is necessary, however, for the application of the factorizing method and multiplication and division exceeding the capacity of the ordinary desk calculator will be encountered. For those unaccustomed to such

List D-2—CIRCULAR FUNCTIONS

Δ—some type of first difference.
PP—proportional parts.
6D—6 decimal places.
6S—6 significant figures.

s—sine
c—cosine
t—tangent
ct—cotangent
sec—secant
csc—cosecant

Author or Maker	Abbreviated Title	Publisher	Natural Values	Logarithmic Value (Base 10)	Other Lists
Inverse Functions (Radians)					
Clements, G. R. Wilson, L. T.	Manual of Mathematics and Mechanics (1947)	McGraw-Hill Book Co. 330 W. 42 St., N.Y. 36, N.Y.	arc s, c, t; 0(.01)1; arc csc, sec, t; 1(.01)1.5(.05)3(.1)6 6(.2)10(.5)15(1.0)25; (be) 4D	.....	B, C, D

Comrie, L. J.	Chambers's Six-Figure Tables Vol. 2 (1949)	D. Van Nostrand Co.
		120 Alexander St., Princeton, N.J.
			arc s, c, t, ct; 0(.001)1, 6D; Δ;
			arc t, ct, sec, 1(.001)2, 6D; Δ;
			2(various)80
				.....	A, B, C, D

CUP-5	Arc sine x (1945)	Out of print.	arc s; 0(.00011).989(.00001)1; 12D; (ba)	.....	.....
Dwight, H. B.	Mathematical Tables (1944)	Out of print.	arc s, c, 0(.001)1, 4D; Δ; arc t, 0(var)50, 4D; Δ; (bg)	.....	C, D
MT-16	Arc tan x (1942)	Out of print. (bb)	arc t, 0(var)10,000 (bd), 12D; (bh)	.....	.....
Degrees and Minutes					
Allen, E. S.	Six-Place Tables (1947)	McGraw-Hill Book Co. 330 W. 42 St., N.Y. 36, N.Y.	s, c, t, ct, sec, csc; 1 min; 6D;	s, c, t, ct; 1 min, 6D; Δ;	B, C, D
Andoyer, H.	Nouvelles Tables Trigonometrique (Valeurs Naturelles, 3 vol, (1915 18)	Out of print.	s, c, t, csc, sec; 10 sec, 15D or more; Δ;	.....	.....
Andoyer, H.	Nouvelles Tables Trigonometriques (Logarithms—1911)	Out of print.	.....	s, c, t, ct; 10 sec; 14D or more; Δ;	.....
Brandenburg, H.	Sechstellige Trig. Tafel (1944)	Edwards Bros. Ann Arbor, Mich.	s, c, t, ct; 10 sec, 6D; Δ; PP;	.....	.....
Bruhns, C.	New Manual of Logarithms (1941)	D. Van Nostrand 120 Alexander St., Princeton, N.J.	.....	s, c, t, ct; (bc) 7D; Δ; PP;	C
Clements, G. R. Wilson, L. T.	Manual of Mathematics and Mechanics (1947)	McGraw-Hill Book Co. 330 W. 42 St., N.Y. 36, N.Y.	s, c, t, ct; csc, sec, 10 min; 4D-5S;	s, c, t, ct; 10 min; 4D	B, C, D
Comrie, L. J.	Chambers's Six-Figure Tables (1949) Vol. 1–2	D. Van Nostrand Co. 120 Alexander St., Princeton, N.J.	s, c, t, ct, sec, csc; 1 min; (bf) 6S, 6D; Δ; (vol. 2)	s, c, t, ct; 1 min; (bf) 6D Δ; PP; (vol. 1)	A, B, C, D
Fowle, F. E.	Physical Tables (8th rev. ed.) Publ. No. 3171	Smithsonian Institution Washington 25, D.C.	s, c, t, ct; 10 min; 4D or 5S	same as natural values, 4D	B, C, D
Peters, J.	Eight-Place Table (1943)	Edwards Bros. Ann Arbor, Mich.	s, c, t, ct; 1 sec; 8D; Δ;	.....	.....
U.S. Coast & Geodetic Survey	Sines and Cosines (Spec. Publ. No. 231) (1942)	Supt. of Documents Washington, 25 D.C.	s, c, 1 sec; 8D; Δ;	.....	.....

Notes:
(ba) Has complete second and a few fourth differences and tables of coefficients for interpolation by Everett and Gregory-Newton formulas.
(bb) Reissued as AMS-26.
(bc) Interval 1 second from 0 to 6 degrees and 84 to 90 degrees; 10 second interval between 6 degrees and 84 degrees.
(bd) Interval of x as follows: 0(.001)7(.01)50(.1)300(1)2000(10)10,000.
(be) Has arc ct above 1.5.
(bf) For natural values has finer intervals for cotangents and cosecants below four deg; for logarithmic values has ten second interval below ten degrees for all four functions; for log sin and log tan has one second interval below 1 deg 20 min.
(bg) Argument interval 0.001 below 1.
(bh) Has second differences and tables of coefficients for interpolation by Gregory-Newton and Everett formulas.

List D-3 HYPERBOLIC FUNCTIONS

Δ—some type of first difference.
V—proportional parts.
V—first variation.
6D—6 decimal places.
6S—6 significant figures.
sinh—hyperbolic sine
cosh—hyperbolic cosine
tanh—hyperbolic tangent
coth—hyperbolic cotangent
sech—hyperbolic secant
csch—hyperbolic cosecant

Author or Maker	Abbreviated Title	Publisher	Natural Values	Logarithmic Values (Base 10)	Other Lists
Hyperbolic Functions					
Allen, E. S.	Six Place Tables (1947)	McGraw-Hill Book Co. 330 W. 42 St., N.Y. 36, N.Y.	sinh, cosh, tanh; 0(.001)1(var)6; 6D;	.....	B, C, D
BA-Vol. 1	Circular and Hyperbolic Functions (1951)	Cambridge Univ. Press 32 E. 57 St., N.Y. 22, N.Y.	sinh πx, cosh πx; x = 0(.0001).01, 15D (ca) x = 0(.01)4, 14–16S; sinh x, cosh x; x = 0(0.1)10, 15D	.....	D
Becker, G. F. Van Orstrand, C. E.	Hyperbolic Functions Publ. No. 1871, 6th reprint	Smithsonian Institution Washington, 25 D.C.	sinh, cosh, tanh, coth; 0(.0001)0.1(.001)3(.01)6 5D; 5-7S; FV;	Same as natural values, 5D; FV;	C, D
Clements, G. R. Wilson, L. T.	Manual of Mathematics and Mechanics (1947)	McGraw-Hill Book Co. 330 W. 42 St., N.Y. 36, N.Y.	sinh, cosh, tanh, coth, sech, csch; 0(.01)3.5(.05)6; 4D; 4-5S;	Sinh, cosh, tanh; 0(.01)3.5(.05)6; 4D	B, C, D
Comrie, L. J.	Chambers's Six-Figure Tables Vol. 1-2 (1949)	D. Van Nostrand Co. 120 Alexander St., Princeton, N.J.	sinh, cosh, tanh, coth; 0(.001)3(var)6(var)100 (cb) 6S; Δ; (vol- 2)	Sinh, cosh, tanh; 0(.001)3(.01)5 6S; 6D; Δ; (Vol. 1)	A, B, C, D
CUP-3	Circular and Hyperbolic Tangents and Cotangents (1947)	Columbia Univ. Press Morningside Heights, N.Y., 27, N.Y.	tanh, coth; 0(.0001)2, 8-10S; (cc) 0(0.1)10, 10D;	.....	D
Dwight, H. B.	Mathematical Tables (1944)	Out of print.	sinh, cosh, tanh; 0(.001)3, 4-6S; Δ	.....	C, D
Flugge, W.	Four Place Tables of Transcendental Functions (1954)	McGraw-Hill Book Co. 330 W. 42 St., N.Y. 36, N.Y.	sinh, cosh; 0(.01)10.09, 4S tanh; 0(.01)5.09, 4D	.....	C, D
Fowle, F. E.	Physical Tables Publ. No. 3171 (8th rev. ed.)	Smithsonian Institution Washington 25, D.C.	sinh, cosh, tanh, coth; 0(.01)3(0.1)5, 5D, 5-6S;	Same as natural values; 5D;	B, C, D
MT-3	Circular and Hyperbolic Sines & Cosines (1949)	Out of print. (cd)	sinh, cosh; 0(.0001)1.9999, 9D 0(0.1)10, 9D (cd)	.....	D
Pernot, F. E. Woods, B. M.	Logarithms of Hyperbolic Functions Univ. of Calif. Publ. in Engrg. (1918) Vol. 1, No. 13.	Out of print.	.....	sinh, tanh; 0(.001)2.018, 12S; (ce) cosh; 0(.001)2.032, 12S	.....
Inverse Hyperbolic Functions					
Clements, G. R. Wilson, L. T.	Manual of Mathematics and Mechanics (1947)	McGraw-Hill Book Co. 330 W. 42 St., N.Y. 36, N.Y.	Inverse sinh, sech, tanh; 0(.01)1, 4D; Inverse sinh, cosh, coth; 1(.01)1.5(.05)3(.10)6 6(.2)10(.5)15(1)25, 4D;	.....	B, C, D
Comrie, L. J.	Chambers's Six-Figure Tables Vol. 2 (1949)	D. Van Nostrand Co. 120 Alexander St., Princeton, N.J.	Inverse sinh, tanh; 0(.001)1, 6D; Δ; Inverse sinh, cosh, coth; 1(.001)2 2(var)80, 6D; Δ;	.....	A, B, C, D
Dwight, H. B.	Mathematical Tables (1944)	Out of print.	Inverse sinh; 0(.001)2(.01)10 4D; Δ; Inverse cosh; 1(.001)2(.01)10 4D; Δ; Inverse tanh, 0(.001)1 4D; Δ;	.....	C, D
HUCL-Vol. 20	Inverse Hyperbolic Functions (1949)	Harvard Univ. Press 44 Francis Ave., Cambridge, Mass.	Inverse sinh; 0–22,980 (cg), 9D; (cf) Inverse cosh; 1–22,980 (cg), 9D Inverse tanh, 0–1, (cg) 9D;	.....	.....

Notes:
(ca) For $x = 0(.0001).01$ has second differences for interpolation by Everett's formula.
(cb) Natural values actually have largest value of tanh and coth 1.000 000 for the argument 7.6; above argument 6, sinh and cosh are calculated as $\frac{1}{2} e^x$ (see Introduction).
(cc) Has some second differences and coefficients for interpolation by Everett and Gregory-Newton formulas.
(cd) Reissued as AMS-36. The range of the main tables of hyperbolic functions was later extended by publication of AMS-45. The latter gives sinh x and cosh x for $x = 2(.001)10$, 9S.
(ce) Auxiliary tables; also certain 1st, 2nd, and 3rd differences for interpolation.
(cf) 1st and 2nd differences provided for interpolation by Gregory-Newton formula.
(cg) Argument interval for inverse sinh ranges from 0.002 to 20; interval for inverse cosh ranges from 0.00001 to 20; and interval for inverse tanh ranges from 0.001 to 0.00001. There are many changes of interval throughout this table.

operations, reference to pages 57-59 of Willers, F. A. *Practical Analysis* (Dover Publications-1948) or Marchant Methods MM 421 A1,2 (Multiplication) and MM 421 B 1,2 (Division) will be helpful. Copies of these and other Marchant Methods may be secured from Marchant Calculator, Inc., Oakland 8, California.

By eliminating the delay-causing "series" calculation used for the full 23-decimal computation, an ingenious computer can rapidly calculate, say 12-figure logarithms and antilogarithms using a calculating machine and straight-line interpolation of the last or smallest "factor," and its logarithm.

AMS-27 is a recently issued table of antilogarithms. Besides other uses for these tables, the labor of interpolation may be entirely eliminated where large quantities of 5-place logarithms must be interpolated to get antilogarithms.

An "auxiliary" table of "Addition and Subtraction" logarithms helps to make certain logarithmic calculations much more efficient. Such as, for example, when evaluating expressions of the form $(a^x \pm b^y)^{1/n}$, and in particular, when solving for roots of higher degree equations by Graeffe's method. "A & S" logs are not shown on List C, however FMR gives a good selection of tables, and an explanation of their use on p. 117. For employment with 6-place common log tables, B. Cohn's table of

"A & S" logs can be purchased from Scientific Computing Service, 23 Bedford Square, London, England.

NATURAL LOGARITHMS—LIST C

Working tables such as Allen, Chambers, Clements and Wilson, Dwight, Flugge, Jahnke and Emde, and Becker and Van Orstrand, described in List C are all contained in volumes mentioned elsewhere in this article.

All of the original MT volumes of natural logarithms described in List C are out of print. However, AMS Vol. 31, recently published, is a reissue of Vol. III (Range 0-5). It is anticipated that a reissue of Vol. IV (MT-12: Range 5-10) may be made by the National Bureau of Standards in the future.

The *Smithsonian Logarithmic Tables* also have 23-place natural logarithms. As in the case of the companion tables to the base 10 (in same volume), this table of natural logarithms is set up for the employment of an easy factorizing method of interpolation previously described in Common Logarithms. ("Radix" method)

A table of 10^x is a table of antilogarithms to the base 10, such as AMS-27, noted in the list of tables of common logarithms. For e^x, the same relationship exists with respect to a table of natural logarithms.

CIRCULAR AND HYPERBOLIC FUNCTIONS—LIST D

List D contains a comprehensive selection of natural and logarithmic values of circular and hyperbolic functions, with arguments for circular functions in: degrees and decimals, radians, and degrees and minutes. Degrees and decimals are becoming more important because of the greater convenience of decimal subdivisions.

AMS-5 and AMS-40 are inexpensive. Flugge is a particularly convenient volume recently issued. Besides containing tables of elementary functions useful for slide-rule work, a number of tables of higher functions are included. Dr. J. Peters was one of the most accurate and indefatigable table makers and several of his volumes occupy a prominent place in List D. The same can be said of Dr. L. J. Comrie, and the set of two volumes of Chambers's *Six-Figure Tables* contains a multitude of elementary tables. Other useful working tables of circular and hyperbolic functions are Allen, Becker and Van Orstrand, Clements and Wilson, and Fowle.

Several notable volumes sponsored or produced by the National Bureau of Standards, including those published by the Columbia University Press, are represented in List D. The inexpensiveness of many of these useful tables makes them very attractive.

Both inverse circular and hyperbolic functions are included in List D, but these will chiefly be of interest to those doing more advanced work. HUCL-20 is a particularly fine example of modern tablemaking, being part of a notable series of volumes mostly concerned with higher functions.

The monumental work of Andoyer commands the respect of all those who have had occasion to use his tables. Both natural and logarithmic values of Andoyer are mentioned in List D.

Although logarithmic values (base 10) are of less use as the calculating machine becomes more common, a listing of logarithmic values of many functions are given for those who do not have a good calculator.

Intervals of argument shown on List D, such as 1 minute, 10 seconds, etc., are those tabled generally. Some tables have special sections with smaller intervals over short ranges. Certain of these have been mentioned, however, no attempt has been made to list more than the standard interval in the majority of tables.

Although tables of the Gudermannian have not been listed in this article, this function can be found in Becker and Van Orstrand, Clements and Wilson, and Comrie (Chamber's Tables).

CURVE FITTING; POLYNOMINALS—LIST E

Under certain conditions, old-fashioned methods of fitting polynominals of higher degree by the method of least squares have been rendered obsolete by the advent of tables of orthogonal polynominals. Use of these tables, however, is subject to one limitation: the data must be uniformly spaced, without gaps, in respect to one variable. For a complete descripture of the theory and application of orthogonal polynominals in curve fitting see *Product Engineering* for April 1956, page 171. Several of the references (tables-List E) are not in book form,

List E—FITTING OF POLYNOMINALS

Author	Abbreviated Title Book or Article	Publisher or Name of Periodical	Range Within Which Polynomials Can Be Fitted, Using Tables	
			Number of Evenly-Spaced Data Points(n)	Degree of Polynomial
Orthogonal Polynomials (Tables)				
Anderson, R. L. Houseman, E. E.	Table of Orth. Polynomials (1942)	Research Bulletin No. 297—Iowa State College Ames, Iowa	3-104	1-5
Birge, R. T. Weinberg, J. W.	Least Squares Fitting of Data	Reviews of Modern Physics—Oct. 1947	3-30	1-5
DeLury, D. B.	Table of Orth. Polynomials (1950)	Univ. of Toronto Press—Toronto, Canada	3-26	1 to (n-1)
Van der Reyden, D.	Curve Fitting—Orth. Polynomials (a)	Onderstepoort Journal of Vet. Science & Animal Industry (Union S. Africa) Vol. 18—Nos. 1 & 2—1943	5-52	1-9
Orthogonal Polynomials (Texts) (e)				
Anderson, R. L. Bancroft, T. A.	Statistical Theory in Research (1952)	McGraw-Hill Co. 330 W. 42nd St., N. Y. 36		
Paradine, C. G. Rivett, B. H. P.	Statistics for Technologists (1954)	D. Van Nostrand Co., 120 Alexander St., Princeton, N. J.		
Methods not Using Orthogonal Polynomials (Tables) (b)				
Kerawala, S. M.	Rapid Method—Least Squares (c)	Indian Journal of Physics—Aug. 1941	1-30	1-5
Nielsen, K. L. Goldstein, L.	Algorithm for Least Squares (d)	Journal Math. & Physics (Mass. Inst. Tech.) July 1947	5-100	1-4

Notes:
(a) These tables have been reproduced on p. 212 of the new *Biometrika Tables* (see footnote to List G); the standard and better "common factor" has been introduced here.
(b) Also require evenly spaced data, without gaps, in one variable.
(c) Discussed in Birge and Weinberg (above), p. 337.
(d) Further explained in Nielsen, (see List F).
(e) Also see Hildebrand, p. 288, etc. (List F), Nielsen (List F), Milne p. 265 (List F); *Product Engineering*, April, 1956, p. 171.

List F—INTERPOLATION TABLES AND METHODS

Author or Maker	Abbreviated Title	Publisher
Tables (a)		
AMS-35	Lagrangian Coeff. for Sexagesimal Interpolation (1954)	Supt. of Documents, Washington 25, D. C.
Nautical Almanac Office U. S. Naval Observatory	American Ephemeris and Nautical Almanac (b) (f)	Supt. of Documents, Washington 25, D. C.
Comrie, L. J.	Chamber's Tables—Vol. II (1949) (c)	D. Van Nostrand Co., 120 Alexander St., Princeton, N. J.
CUP-4	Lagrangian Coefficients (1948)	Columbia Univ. Press, Morningside Heights, N. Y. 27
H. M. Nautical Almanac Office	Interpolation and Allied Tables (1956) (b) (d)	British Information Services, 45 Rockefeller Plaza, N. Y. 20
Kelley, T. L.	Kelley's Statistical Tables (1948) (e)	Harvard Univ. Press, Cambridge, Mass.
Thompson, A. J. (TC-5)	Coefficients—Everett's Central Difference Formula (2nd ed. 1943)	Cambridge Univ. Press, 32 E. 57th St., N. Y. 22
Methods		
Hartree, D. R.	Numerical Analysis (1952	Oxford Univ. Press, 114 5th Ave., N. Y. 11
Hildebrand, F. B.	Introduction to Numerical Analysis (1956)	McGraw-Hill Book Co., 330 W. 42nd St., N. Y. 36
Milne, W. E.	Numerical Calculus (1949)	Princeton Univ. Press, Princeton, N. J.
Nielsen, K. L.	Methods in Numerical Analysis (1956)	MacMillan Co., 60 5th Ave., N. Y. 11
Scarborough, J. B.	Numerical Mathematical Analysis (3rd ed. 1955)	Johns Hopkins Press, Baltimore, Md.

Notes:
(a) Short tables of coefficients will also be found in the books listed below for example, Milne (Everett, Lagrange); Nielsen (Bessel, Everett, Lagrange); a compact set of Lagrange coefficients is in Dwight (see lists C, D).
(b) Bessel and Everett coefficients.
(c) Bessel coefficients; certain Lagrange values. Condensed tables of Bessel coefficients will be found in Chamber's "Shorter" Tables.
(d) This publication has recently been reprinted again, in a revised edition. Certain tables of coefficients, etc., found therein or in previous reprints, were taken from the British Nautical Almanac for 1931 (p. 828); 1935 (p. 742); 1937 (pages 784-809, 839, 926-943). A valuable companion booklet, entitled "Subtabulation," is expected to be published for the first time in 1957.
(e) Comprehensive tables of Lagrangian coefficients.
(f) These tables appear in each year's volume, starting with 1951.

and probably will be available for examination only in the largest city and university libraries. Included in the papers listed are two modern methods which do not employ orthogonal polynomials, but which nevertheless have certain advantages over older methods.

A stimulating book for curve-fitters and other computers is the recently issued *Approximations for Digital Computers* by Hastings, C. Jr., Hayward, J. T. and Wong, J. P., Jr. (Princeton University Press-1955). Many of the ideas and tabulations in this volume can be used for applications not involving automatic computers.

INTERPOLATION—LIST F

The late L. J. Comrie, one of the best known authorities on the subject, has stated that modern interpolation, in general, has narrowed down to the use of the formulae of Bessel, Everett, and Lagrange. However, many modern computers frequently favor Lagrangian interpolation, because it is well-suited for use with a desk calculator.

Listed tables give interpolation coefficients and procedures for these formulae. In order to avoid confusion, it should be noted that Bessel functions are not interpolation tools; they are solutions of differential equations, and have no direct connection with the subject of interpolation as do Bessel coefficients. CUP-4 is a very comprehensive table, giving Lagrangian coefficients to 10 decimal places for very small intervals. Few interpolation tables are available for arguments in sexagesimal measure, and AMS-35 listed below enables the computer to avoid cumbersome procedure of using the more common tables with decimal subdivisions of the argument. Under certain conditions, AMS-35 may be used for decimal intervals, although not as efficiently as CUP-4. In an emergency, good tables of Everett interpolation coefficients are included in the appendix of any one of AMS-5, 20, 26, 28, 32; CUP-3, 5, 11; HT-5, 6, 13, 16.

Among the books and articles listed, Hartree includes a good summary of modern interpolation methods. Hildebrand gives an excellent theoretical discussion. Milne, Nielsen and Scarborough cover the practical aspects, each reinforcing the other in important areas.

HARMONIC ANALYSIS

A number of tables for harmonic analysis have been published, however, most of them have gone out of print. A list of some of the best-known tables will be found in MTAC-April 1944, p. 193. At the present time, Professor L. W. Pollak seems to be one of the few authors whose tables are still in print. Descriptions of his tables will be found in the following issues of MTAC: July 1947, p. 306; Jan. 1951, p. 19; July 1951, p. 149; April 1955, p. 72. At the present moment, the following publications (or subsequent editions) described in MTAC are in print: *Harmonic Analysis and Synthesis Schedules, etc.* (1947 ed.); *All Term Guide for Harmonic Analysis and Synthesis, etc.* (1949 ed.); *Eight-Place Supplement to Harmonic Analysis and Synthesis Schedules, etc.* (1954 ed.).

The first two publications are available and may be purchased from The Stationery Office, Dublin, Ireland. The *Eight-Place Supplement* may be purchased from the Dublin Institute for Advanced Studies, School of Cosmic Physics, 5 Merrion Square, Dublin, Ireland, at the price shown in MTAC.

Fletcher, Miller and Rosenhead's *Index* contains a good discussion of tables and schedules for harmonic analysis (p. 367).

TABLES RELATING TO HIGHER FUNCTIONS

Higher functions have had very extensive treatment in the literature. Only an informal indication of the tables available (both in print and out of print) can be given here. They include:

Erdelyi, A., Magnus, W.; Oberhettinger, F.; and Tricomi, F. G., *Higher Transcendental Functions* Vols. I-II (1953) (mostly text); and *Tables of Integral Transforms*, McGraw-Hill Book Co., 330 W. 42nd St., N. Y. 36, N. Y.

Jahnke, E. & Emde, F., *Tables of Functions* (4th revised edition) Dover Publications, 920 Broadway, N. Y. 10, in which a substantial number of errors were corrected in the most recent edition. (This volume also has some useful tables of elementary functions.)

Jahnke & Emde, and Erdelyi specialize in higher functions, and since they cover virtually all of the classifications given below (Bessel, Legendre, Mathieu, etc.,) no effort has been made to itemize their contents here.

Jahnke & Emde has also been available in European editions (see MTAC issues for details of history). In addition to elementary functions, the indexes of FMR and Davis, and articles in MTAC give a wide coverage of higher functions (see list G).

Of the books in Lists A to D, Allen, Comrie (Chambers's Tables), Clements & Wilson, and Dwight and Fowle include some material on various higher functions, as classified below. Flugge and BA-Vol. I have more comprehensive tables for certain higher functions.

The expressions "see List C, D, etc.," below are merely tie-in references; they do not mean that the higher function in question is shown on those lists. Lists A-D generally give details of elementary functions only.

BESSEL FUNCTIONS

AMS-1 (reissued as AMS-25), AMS-28, 37; BA-Vol. 6, 10; CUP-2, 8, 9, 10, 11, 12; Dwight (see List C, D); Flugge (see List B, C, D); Fowle (see List B, C, D); HUCL Vols. 2-14. The entire July 1944 issue of MTAC was devoted to a very comprehensive guide to tables of Bessel functions. Although out of print Enzo Cambi's many-place table of Bessel functions (1948) can still be found in stock at a few bookstores.

LEGENDRE FUNCTIONS

AMS-37-38; BA-Part Vol. "A"; CUP-6; Dwight (see List C, D); Fowle (see List B, C, D); MT-15 (superseded by AMS-19), MT-18 (reissued in AMS-37).

MATHIEU FUNCTIONS

CUP-13; MT-37. Lists of tables relating to Mathieu functions will be found in MTAC as follows: July 1945, p. 409-419; Jan. 1946, p. 1-11.

ELLIPTIC FUNCTIONS AND INTEGRALS

AMS-38; Dwight (see List C, D); Clements and Wilson (see List B, C, D); Flugge (see list C, D); Fowle (see List B, C, D); Smithsonian Publications Nos. 2672 and 3863. The Oct. 1948 issue of MTAC has a very comprehensive guide to tables of elliptic functions and integrals. An important and more recent addition is the handy little *Jacobian Elliptic Function Tables* of L. M. Milne-Thomson (Dover Publications 1950).

SINE, COSINE AND EXPONENTIAL INTEGRALS

BA-Vol. 1 (see List D); Flugge (see List B, C, D); Fowle (see List B, C, D); HUCL-Vols. 18, 19, 21; MT-5, 6, 13 (reissued as AMS-32).

ERROR AND PROBABILITY FUNCTIONS

AMS-6, 22; BA-Vol. 7; Clements and Wilson (see List B, C, D); Comrie (Chambers's Tables-Vol. 11); Dwight (see List C, D); Flugge (see List B, C, D); HUCL-Vol. 23, 35; MT-8 (reissued as AMS-41); MT-14 (reissued as AMS-23); *Biometrika Tables* (see footnote to List G); AMS-21 is a guide to tables of the normal probability integral.

HYPERGEOMETRIC FUNCTION

AMS-3, 7; MT-15 (superseded by AMS-19).

GAMMA FUNCTIONS

AMS-16, 34; BA-Vol. 1 (see List D); Comrie (Chamber's Tables, Vol. I-II); Dwight (see List C, D); Flugge (see List B, C, D); Fowle (see List B, C, D); TC-4, 8, 9; Pearson K. (see List G). *Biometrika Tables* (see footnote to List G).

RIEMANN ZETA FUNCTION

Dwight (see List C, D). AMS-37 has a rare and valuable table of $X^n/n!$ which is extremely useful when making certain computations with Taylor and Maclaurin series. AMS-39 contains a very helpful article by L. Fox, illustrating the solution of simultaneous equations by various methods. The recently-issued HUCL-40 *Table of Arc Sin z* is an extensive table of a function of a complex variable, which will probably be of interest primarily to electrical engineers.

AMS-9 is a very useful table for those doing work with Chebyshev polynomials. This book has an extraordinarily informative introduction concerning the use of these polynomials in curve fitting and solution of differential equations. The new volume of tables, *Spheroidal Wave Functions*, by Stratton, Morse, Chu. Little and Corbato will enable the applied physicist and engineer to handle wave problems in spheroidal coordinates with greater facility.

TABLES ON PUNCHED CARDS

A great many tables have been constructed in past years, using punched cards. *A Guide to Tables on Punched Cards* was published in the Oct. 1951 issue of MTAC, p. 185-212. A comprehensive index of such tables is given in that article, which includes the type of table, a brief description, the source of the original tables (if known), and where the punched-card table is available. An addendum to the Oct. 1951 list will be found in MTAC, Jan. 1953, p. 1-6. Reprints of these MTAC articles have been available without charge through the Applied Mathematics Division of the National Bureau of Standards, Washington 25, D. C.

It is interesting to note that "looking up" values in punched-card tables has been dispensed with in the most up-to-date automatic computing machinery. Values of *sin x*, *arc tan x* and other functions are swiftly and directly computed from infinite series or continued fraction expansions or approximation formulas such as those tabulated in Hastings, Hayward and Wong described elsewhere in this article.

MISCELLANEOUS TABLES, GUIDES—LIST G

Kent and Kent contains all compound interest functions ordinarily needed by the engineer. These tables are reproduced in Dyess and Gilmore. In the introduction, examples are worked out to show the manner of use of the various functions, and methods of interpolation are discussed. Tables I to X, give decimal values of compound interest functions, while Table I(a) gives 15-decimal values of the compound amount of 1 for 15 fractional rates of interest below one percent. The various compound interest function tables may be used to calcu-

late results for time intervals ranging up to 300 years, at interest rates varying from ¼ of 1% to 10½%.

Gushee's *Compound Interest and Annuity Tables* is another set of 10-decimal values. At present, values are computed for relatively fine interest intervals; the volume may be reissued this year with finer intervals.

Glover has a diverse collection of tables, useful for statistical calculations, compound interest computations, interpolation, and curve fitting. A number of the tables are useful for other computational work. Bruhn's seven-place tables of logarithms of numbers (see List C) (not including trigonometric functions) are included.

AMS-22 is of interest when studying extreme values, such as floods and droughts, strengths of materials, etc.

Dodge and Romig provide single and double sampling inspection tables. Freeman, Friedman, Mosteller and Wallis, among other tables and charts, contain a system of multiple sample inspection plans corresponding to the single and double inspection plans. Hald, with accompanying tables, gives a broad theoretical discussion of statistics. Among the subjects covered are those of sampling and Poisson distributions. Table I of Molina gives the individual terms of the Poisson formula. Table II gives accumulated terms, useful in problems of single, double and multiple sampling.

Included among other useful tables in Pearson (and the recently issued successor *Biometrika Tables*) is one giving the sums of powers of consecutive natural numbers, such as $S = 1^z + 2^z + 3^z + \ldots\ldots + n^z$ for values of n from 1 to 100, and powers from 1 to 7 inclusive. Also, sums of powers of odd consecutive integers are given in Pearson, but not in the successor table. Although these summations can be calculated by formula, the use of tables is convenient where many values must be obtained rapidly, as in extensive least square calculations where orthogonal polynomials or other modern methods are not being used. Waugh also has a similar table, with values of n from 1 to 40 and powers from 1 to 6; likewise, there is a companion table of sums of powers of odd numbers. Romig's *50—100 Binomial Tables* give individual and cumulative terms of the point binomial, useful in connection with sampling.

Three guides or indexes to mathematical tables, and one periodical may serve as valuable reference. Fletcher, Miller and Rosenhead is an excellent guide to many varied functions of mathematics. The incidental mathematical discussion is also helpful, and the location of errors in certain tables is noted. An exceptionally bibliography is included at the back of this volume.

Davis is a simple bibliography of tables, and does not have the mathematical discussion and comment on errors found in Fletcher, Miller and Rosenhead.

D. H. Lehmer's *Guide to Tables in the Theory of Numbers* is a more specialized volume. Number theory is less "practical" than some other divisions of mathematics, and this guide will not be as useful as FMR or Davis to those working in calculus and differential equations, statistics, engineering, physics, etc. Nevertheless, it will assist in the solution of some practical problems, such as the factorization of numbers or identification of prime numbers, rapid identification of non-square and non-cube numbers by digit endings, and special binomial congruences (splicing of telephone cables). A comprehensive list of errors in factor and other tables is given, also an excellent bibliography. The location of many tables among 37 large university and city libraries in the United States and Canada, is tabulated.

The quarterly periodical known as *Mathematical Tables and Other Aids to Computation* (abbreviated MTAC) was first published in 1943. It serves as a clearing house for all sorts of mathematical work, containing articles, reviews of new books, and reviews of new tables. Lists of errors in old and newer tables are published as received from contributors from all over the world.

List G—MISCELLANEOUS TABLES, INDEXES

Author or Maker	Abbreviated Title	Publisher
Compound Interest Tables: Miscellaneous Collections		
Dyess, W. B. Gilmore, R. O.	Math. of Business and Finance (1942) (a)	McGraw-Hill Book Co., 330 W. 42nd St., N. Y. 36
Glover, J. W.	Tables of Applied Mathematics (1951)	Wahr's Book Store, Ann Arbor, Michigan
Gushee, Chas. H.	Compound Interest and Annuity Tables	Financial Publishing Co., 82 Brookline Ave., Boston 15, Mass.
Kent, F. C. & M.E.	Compound Interest and Annuity Tables (1926) (a)	McGraw-Hill Book Co., 330 W 42nd St., N. Y. 36
Statistics, Sampling		
AMS-22	Probability Tables-Analysis of Extreme-Value Data (see AMS-33 for applications) (1953)	Supt. of Documents, Washington 25, D. C.
Bowker, A. H. Goode, H. P.	Sampling Inspection by Variables (1952)	McGraw-Hill Book Co., 330 W. 42nd St., N. Y. 36
Dodge, H. F. Romig, H. G.	Sampling Inspection Tables (1944)	John Wiley and Sons, 440 4th Ave., N. Y. 16
Freeman, H. A. Friedman, M. Mosteller, F. Wallis, W. A.	Sampling Inspection (1948)	McGraw-Hill Book Co., 330 W. 42nd St., N. Y. 36
Hald, A	Statistical Theory with Engineering Applications (1952) Statistical Tables and Formulas (1952)	John Wiley and Sons, 440 4th Ave., N. Y. 16
Molina, E. C.	Poissons Exponential Binomial Limit (1942)	D. Van Nostrand Co., 120 Alexander St., Princeton, N. J.
Pearson, Karl	Tables for Statisticians (Vols. I-II) (b)	Out of print
Waugh, A. E.	Statistical Tables (1952)	McGraw-Hill Book Co., 330 W. 42nd St., N. Y. 36
Romig, H. G.	50-100 Binomial Tables (1953)	John Wiley and Sons, 440-4th Ave., N. Y. 16
Indexes, Guides, Periodical		
Davis, H. T.	Bibliography of Math. Tables (1949) (c)	University Bookstore, Northwestern University, Evanston, Ill.
Fletcher, A. Miller, J. C. P. Rosenhead, L.	Index of Math. Tables (1946) (d)	McGraw-Hill Book Co., 330 W 42nd St., N. Y. 36
Lehmer, D. H.	Guide to Tables in Theory of Numbers (1941)	Out of print
National Research Council	Mathematical Tables and Other Aids to Computation (Quarterly periodical)	National Research Council Natl. Academy of Sciences, 2101 Constitution Ave., Washington, D. C.

Notes:
(a) Kent's tables, as described in the text of this article, are in both these volumes; the same tables can also be found in the following out-of-print books: Kent, F. C. *Mathematical Principles of Finance* and Mackenzie, D. H. *Mathematics of Finance*.
(b) A complete recasting of these two volumes was recently begun by the publication of *Biometrika Tables for Statisticians* Vol. 1 (1954) (Cambridge University Press, 32 E. 57th St., N. Y. 22).
(c) Only a few copies printed.
(d) Out of print. A new edition may be available in 1957.

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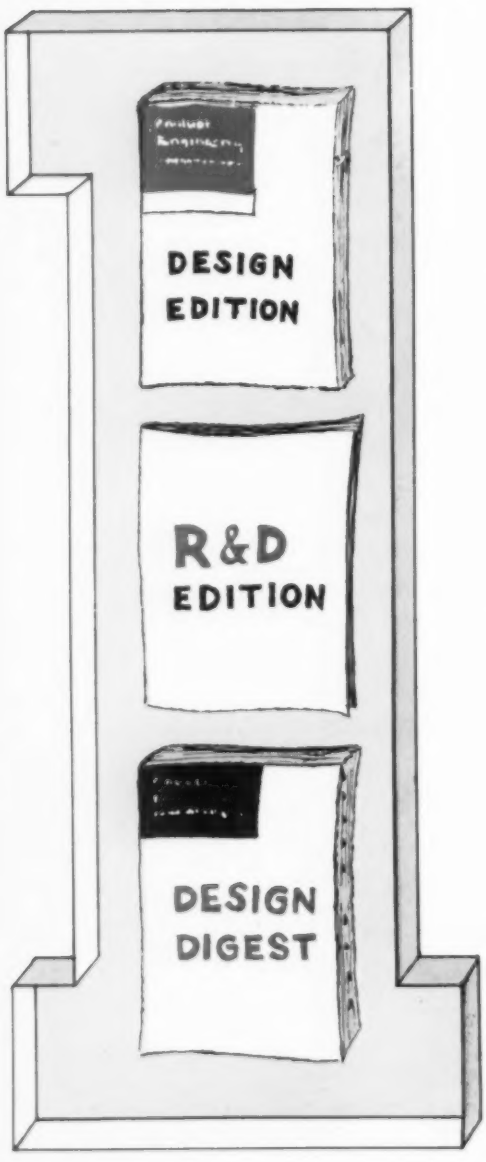

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. . . THE EDITORS

Vectors Simplify Tolerance Analysis

W. HANKA, *Dipl. Ing.*
Military Aircraft Factory
Corboda, Argentina

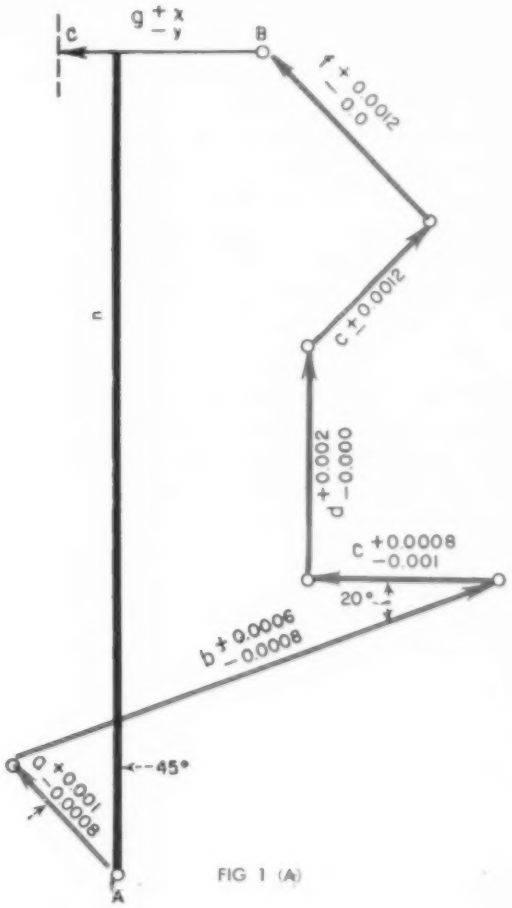


FIG 1 (A)

Analysis of tolerances for non-parallel, non-rectangular dimensions is complex by mathematical methods. Here is a graphical approach, with three sample problems.

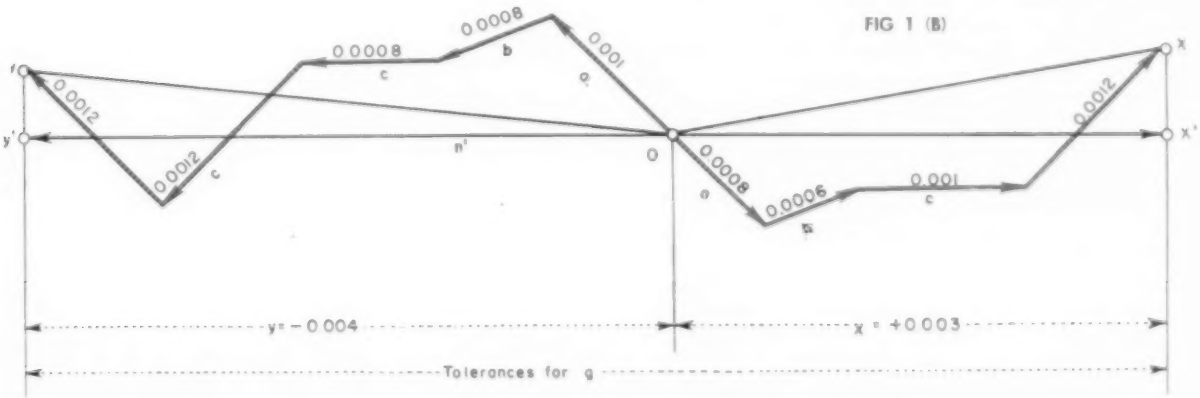
TOLERANCES of parts, mechanisms, or hole locations, which include non-parallel and non-rectangular dimensions, Fig. 1(A), are complex to analyze and may require the solution of a series of trigonometric equations. This graphical method avoids the complexity by setting up two vector diagrams—one giving the relationship of the dimensions across any desired measurement, and the other the magnitude of the tolerances. Three sample problems illustrate the method:

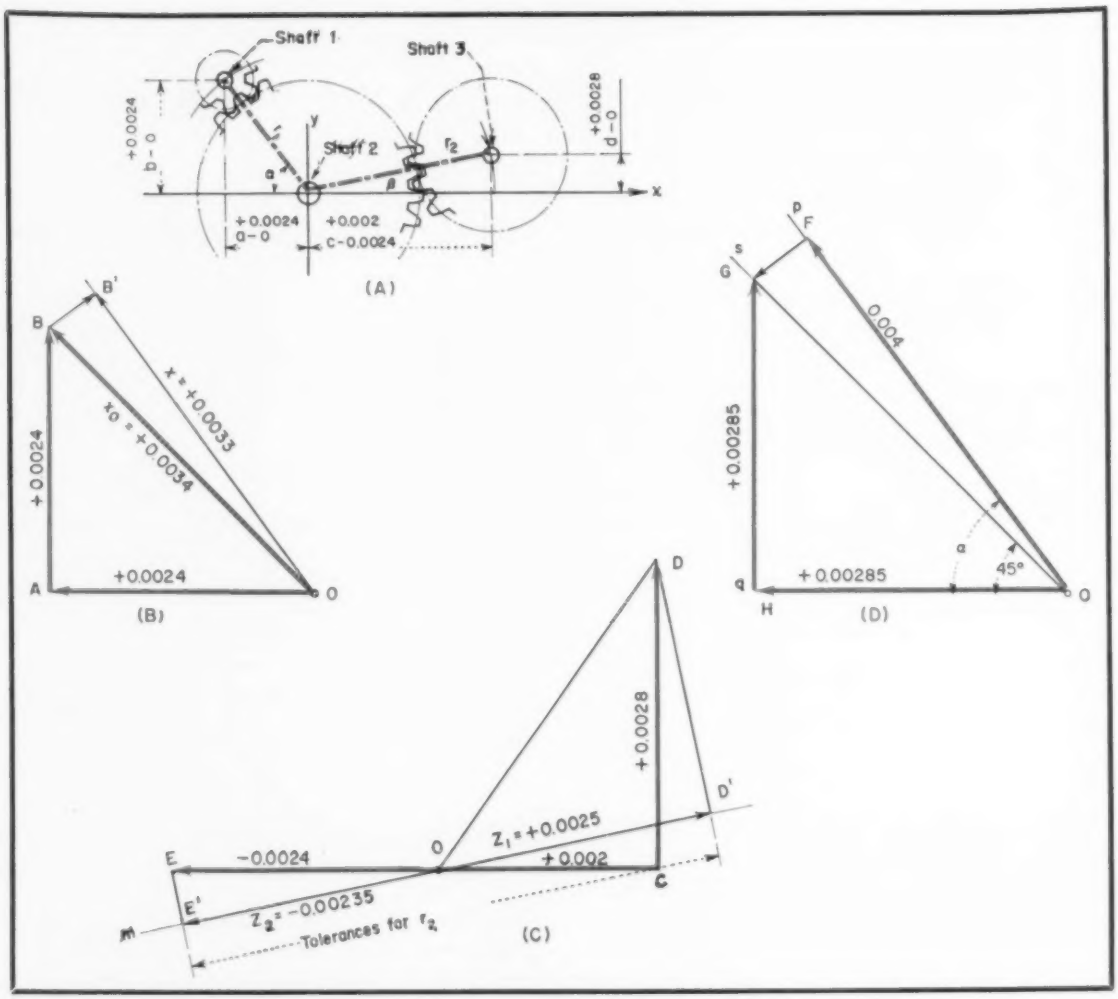
Example 1

In Fig. 1(A), the position of point *B* in relation to point *A* is given by a series of dimensions a, b, c, . . . with their corresponding tolerances. Find the tolerance for dimension g resulting from the tolerances of the other dimensions.

Dimensions are drawn to scale without any attempt to include the tolerances. For example, dimension b may be 3 in., dimension c may be 1.25 in., etc. Arrows on the dimensions point continuously toward *B*. Line *n* is drawn at right angles to *g* (length of *g* does not influence the analysis). This line acts as a reference; any tolerance which tends to pull *n* toward the left

FIG 1 (B)





contributes to the minus tolerance of g, and any which tends to pull n toward the right contributes to the plus tolerance. Thus two groups of tolerances are selected:

(1) Tolerances that increase dimension g:
$-0.0008, +0.0006, -0.001, +0.0012$

(2) Tolerances that decrease dimension g:
$+0.001, -0.0008, +0.0008, -0.0012, +0.0012$

Tolerances parallel to n do not affect g and are neglected. Tolerances in the two groups are now added vectorially by constructing a second vector diagram, Fig. 1(B), in which each tolerance is laid out parallel to its dimension. Thus from a starting point O, Group (1) of the tolerances are laid out to the right of O, using a sufficiently large scale, for example, 1000 to 1. Line n' is drawn through O, at right angles to line n. The projections $O'X'$ and $O'Y'$ of the resultants OX and OY are the tolerances of g: $x = +0.003$, $y = -0.004$.

Example 2

Locations of the shafts in the gear train, Fig. 2(A), are given in rectangular coordinates by dimensions a, b, c and d. Distances r_1, and r_2 between centers can easily be found algebraically. Find tolerances for r_1 and r_2.

From starting point O, Fig. 2(B), tolerances are drawn to scale parallel to their dimensions a and b and added vectorially, resulting in x_0. Projection of x_0 on to line OB' drawn parallel to line r_1 is the tolerance of r_1.

To obtain the tolerance for r_2, two vectorial additions of the tolerances of c and d are made from point O in Fig. 2(C). Tolerances which decrease r_2 are added to the left of O; tolerances which increase r_2 are added to the right. Projections of lines OE and OD on to line m, which has been drawn parallel to r_2, give tolerances $+0.0025$ and -0.00235.

Example 3

Vectors can also be applied to tolerances of dimensions given in polar coordinates. For example, if the location of shaft 1, Fig. 2(A), is given by r_1 with a tolerance of $+0.004$ and by angle α, find the tolerances for a and b with the condition that both tolerances to be equal.

From point O of Fig. 2(D), line p is drawn parallel to r_1 and the tolerance 0.004 marked off on in, locating point F. To get equal tolerances, line s is constructed at 45° and a perpendicular from point F locates point G. Projecting G down to line q locates point H. Tolerances for a and b are measured off as 0.00285 inches.

HYDRAULIC CONTROL VALVES

V—Valve Circuits

JOHN J. PIPPENGER
Double A Products Co. Manchester, Michigan

Beyond serving in their obvious capacities as pressure, flow or directional control valves, standard combinations of these components result in configurations designed to perform specialized functions. Regenerative, tandem and high-low circuits are among the most familiar forms. Factors governing the choice of valve, its function in the circuit and the problems that may be anticipated and avoided are discussed in this last article in the valve series.

Regenerative Circuits

A typical regenerative circuit would operate thus: (a) Rapid approach of cylinder with rod and blind ends of cylinder tied together for regeneration. (b) Rapid return (pressure at rod end and blind end open to tank).

This requires a four-way valve wherein pressure is connected to both cylinder ports in neutral position. As shown in Fig. 1, the spool will operate conventionally in either extreme position.

Assume a cylinder so constructed that the rod area is one-half of the blind-end area. With a 15-gpm pump and the valve in neutral 15 gpm enters at the pressure port. Tank port is blocked. Considering cylinder port two as the blind end, 15 gpm enters this port. Even though pressure is connected to cylinder one port, or the rod end, 15 gpm is delivered out of the rod end to join with the incoming 15 gpm from the pump because of the differences in area, creating a flow of 30 gpm to cylinder two port during the regenerative cycle. A 30-gpm valve sounds large when used with a 15-gpm, but there are several advantages to this system.

Saving in cost of piping. The largest flow through the cylinder lines would be 30 gpm from cylinder two port to the blind end of the cylinder. This might be piped with 1-in. pipe or tubing. The opposite cylinder line would carry 15 gpm, requiring either ¾- or 1-in. pipe or tubing. The pressure line would only need be ½- or ¾-in. pipe or tubing, and the tank line which would only carry a possible 30 gpm could be either 1- or 1¼-in. pipe or tubing. Thus, the valve body could be purchased with 1¼-in. pipe taps even though the larger capacity was being used in the internal parts. The 1¼-in. pipe taps would be bushed to the desired size. If a flange-connected valve were used, it would be possible to obtain reducing flanges so that bushings would not be required. Only one valve is used in this installation. In other regenerative circuits, more valves are required and, consequently, more piping and associated fittings.

Simplicity of maintenance. The fact that all of the valving is contained in one package certainly lends itself to easy maintenance.

Over-all cost. In some models the cost of one large valve is equal or less than the cost of several small valves

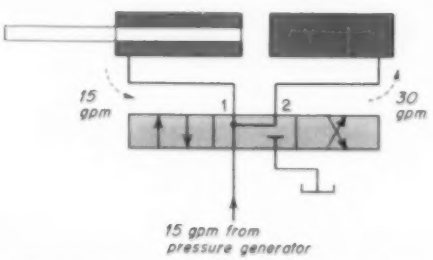


Fig. 1—Simplest form of regenerative circuit has only three functions: rapid forward, full-pressure forward, full-pressure return.

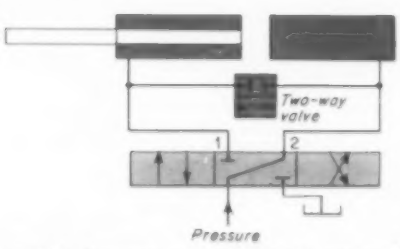


Fig. 2—With four-way valve in neutral, return flow is shut off and by intermittent operation of the two-way valve the piston may be inched forward. With two-way valve open, the circuit operates exactly like that of Fig. 1.

to obtain the same results. Consequent space economies can laso be expected inasmuch as one big valve will often go in a much smaller space than several smaller valves.

However, there are some disadvantages. With the circuit previously described, it is difficult to inch the circuit for setup purposes. There are only three functions: regenerative rapid forward, full-pressure forward, full-pressure return.

With the addition of another two-way valve between the cylinder ports for the regenerative function, as shown in Fig. 2, four functions are obtained. It is now possible to use a partially closed center four-way valve so that "stop" position is available and the cylinder can be stopped at any convenient point in the circuit for setup, safety or stroke-limiting operations. Stop is achieved by centering the four-way valve and blocking with the two-way valve.

Acceleration or deceleration requirements are also more easily controlled with the use of a combination of valves. The single-valve circuit offers considerable resistance to flow and throttling is difficult.

The manner in which the cylinder is to be controlled is arbitrary. If it is primarily a manual operation wherein the operator is the controlling influence, then four-way valve may be lever operated, pilot operated with a remote manual pilot valve or solenoid controlled with the operator actuating pushbuttons. Valves are also manufactured with various air piloting mechanisms. Whether control is by lever, solenoid, oil pilot, air pilot, or some combination is a function of the application and the economics of the circuit.

Several points must be considered carefully when designing regenerative circuits. Even though the following items may seem basic, they are often overlooked:

(1) The piston, when traveling forward during the regenerative cycle, has only a driving force created by the effective area of the rod passing through the packing.

(2) When the full effective force of the head end is desired, rod end must be connected to tank.

(3) When the cylinder is returning, twice as much oil is ejected from the head end as that being introduced in the rod end (assuming a 2:1 rod).

(4) If flow of oil is restricted from the rod end by a metering device, pressure intensification may be severe because of the area ratio on the two piston faces. If the restrictive device on the rod end were closed accidentally, 3000 psi could be intensified to 6000 psi. This is not a remote possibility; it happens with unfortunate regularity. If any restriction in the form of a metering or deceleration device is used in a regenerative circuit, consideration should be given to the introductio of a relief valve on the rod end ahead of the restrictive device which will limit the pressure to a safe value.

(5) Careful consideration should be given to the use of relatively high velocity through the pipe lines during the regenerative cycle. During this part of the cycle, the work being performed is usually the rapid movement of the machine part from one position to another. A slight increase in pressure because of high-

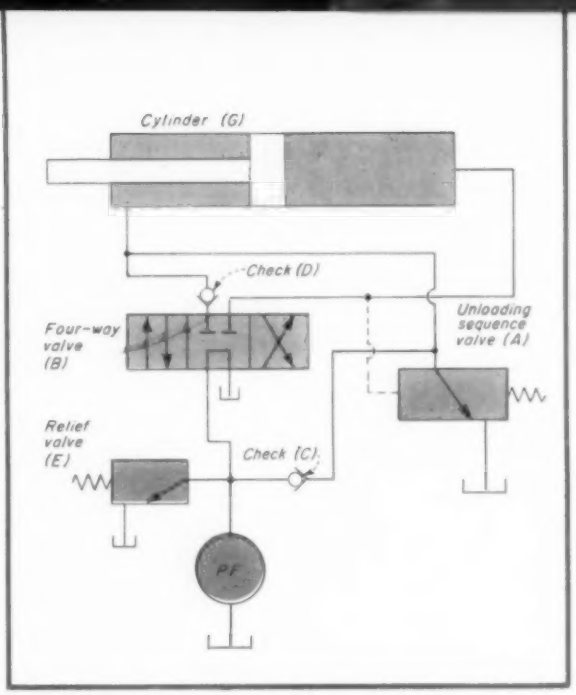


Fig. 3—Regeneration is set up on the forward piston stroke of this circuit and is maintained until work resistance is met. Valve *A* then unloads the rod end to tank and full pressure is applied at the head end. Piston return is standard.

velocity flows through the piping at this time may not cause difficulty and save expense and space.

(6) There must be an adequate supply of fluid in the reservoir so the displacement of the larger-than-normal rod will not lower the oil level unduly when it is in its extreme out position. Several cylinders pulling from the same reservoir may create this condition.

A simple regenerative circuit made up entirely of standard "garden variety" valves is shown in Fig. 3. Assume first that valve *B* is a two-position valve. With the valve shifted so that pressure is on the rod end of *G*, a static condition will prevail wherein the flow path is through the check value *D*, to the rod end. There is no pilot pressure to actuate valve *A* so this line is essentially a dead end. Check valve *C* will be closed. Head end flow is to tank through valve *B*.

When the four-way directional control valve is reversed so that pressure is directed to the head end of *G*, the piston will advance. Oil from the rod end cannot go through check valve *D* nor can it go through valve *A* until pressure rises to a point equivalent to the setting of valve *A* in the head end line. There is a path through check valve *C* so that the oil from the rod end will join that coming from the pump and provide the regenerative action.

When the piston rod on cylinder *G* reaches sufficient resistance to build up the pressure in the pilot line to valve *A*, valve *A* starts to open and oil will be diverted from the rod end of the cylinder through valve *A* back to the reservoir rather than through check valve *C*. This will provide maximum force on the cylinder by providing a flow path from the rod end of *G* so that there is no back pressure.

When valve *B* is again shifted to return the rod of cylinder *G*, pilot pressure will be released from valve

A and it will close. Oil flows through check valve *D* to the rod end, and the head end is connected to tank. The piston will return to the end of its stroke and the pump will dump over the relief valve *E*.

If valve *B* were a closed-center three-position, four-way valve, the cylinder could be inched in either direction but pump flow would have to dump over the relief value. If valve *B* were an open-center valve, the pump would dump in neutral. If there is any tendency for cylinder G to drift out on the differential pressure, check valve *C* may be loaded somewhat to prevent the rod end oil from leaving the cylinder. In extreme cases, valve C could be supplemented with a low-pressure sequence valve to lock the oil in the rod end of cylinder G and prevent drift.

If valve *B* were a tandem-type valve as shown in Fig. 3, there would still be a flow passage through valve *C* from the rod end cylinder line to tank in neutral position so that the rod end cannot be considered locked.

Valve *B* must be of sufficient size to handle the pump flow plus the flow from the rod end of the cylinder without creating a pressure drop incompatible with the circuit requirements. Valve *A* only needs to be sufficiently large to handle the pump delivery minus the displacement of the rod. For example, if *P* delivered 10 gpm and cylinder G were a 2:1 cylinder, then valve A need handle only 5 gpm. The same flow characteristics are true of valve *C*. Valves *D* and *E* need only handle pump capacity.

The manner in which valve *B* is actuated is unimportant. It will work equally well manually, electrically, or through some remote piloting method. Likewise, the manner in which the signal reverses the action of valve *B* could be through limit switches, cam valves, pressure switches, or any other device that provides a signal compatible with the type of controls used. The change from regenerative action to conventional action is automatic by the pressure signal to valve A. The piston will have a return speed equal to the regenerative fast forward. Standard forward speed under full load is half the fast forward speed.

Tandem Circuits

Tandem circuits are series circuits, and normally only one valve is used at a time. Since flow through the valve is in series, if the first valve in the series is operated the exhaust oil under pressure passes through the remaining valves in the circuit as shown in Fig. 4. Oil passing through subsequent pipes and valves will cause back pressure. A second valve should not be operated simultaneously with the first or a loss of force will result due to additional back pressure.

Tandem circuits are considered foolproof circuits because of their inherent sequencial operation. Only one valve can be used effectively at one time, and there is only one common path for the fluid through the circuit. Another bonus is the fact that when all valves are in neutral, the pump is idling at a minimum pressure value, depending only on frictional losses of fluid passing through the circuit.

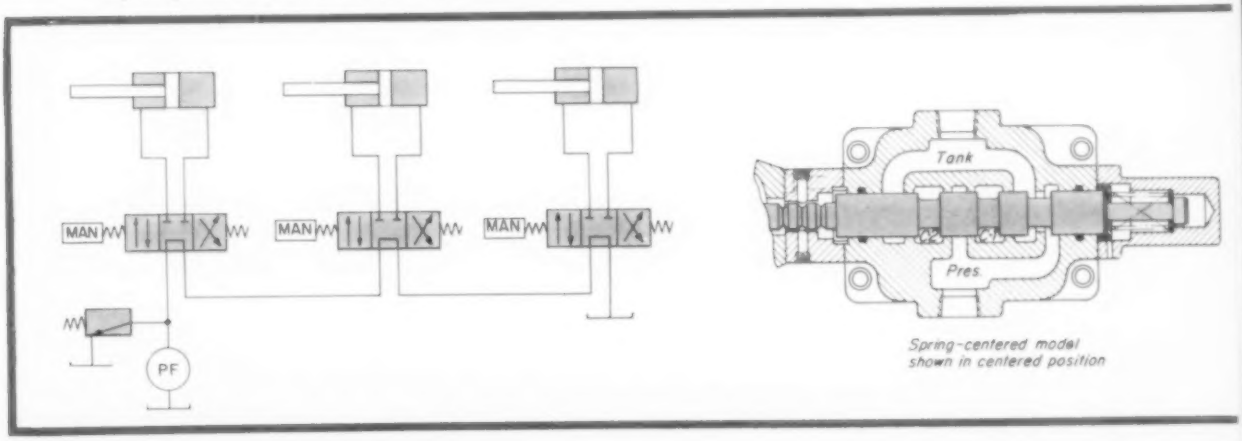
If a vertical cylinder is used in a circuit with a tandem valve with a partially open crossover, the cylinder may drop as the valve is shifting prior to starting in the up direction. If the cylinder is counterbalanced, this is not a problem. In some installations it is not economically feasible to control the cylinder with a counterbalance valve and the closed-center crossover is necessary.

In other installations a partially open center condition is desirable to prevent a rise in pressure as the valve shifts. If the partially open center spool is used and is compatible with the other circuit requirements, it is often possible to minimize inherent shock.

When one tandem-type directional valve is used it is usually satisfactory to use the valve with an integral drain for the shaft packing. (Shaft packing drained into the tank port of the valve.) If several tandem valves are to be used in series with internal drains, packing glands must be included on the end of the spool or a balanced spool design used with high-pressure packing mounted directly on the spool, Fig. 5. In most cases an externally drained valve is preferable, Fig. 6,

Fig. 4—Tandem circuit permits operation of several cylinders from one pressure source. Only one cylinder may be operated at a time without major pressure loss.

Fig. 5—Tandem valves with internal drain require high-pressure packings to prevent oil leakage.



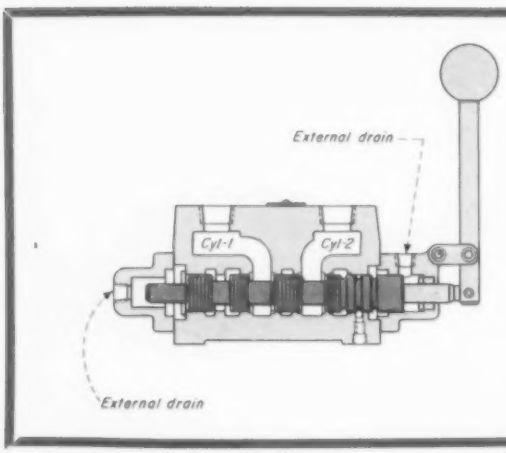


Fig. 6—When externally drained, a four-way tandem valve does not require packings. Drains eliminate sensitivity to back pressures which may unbalance the spool.

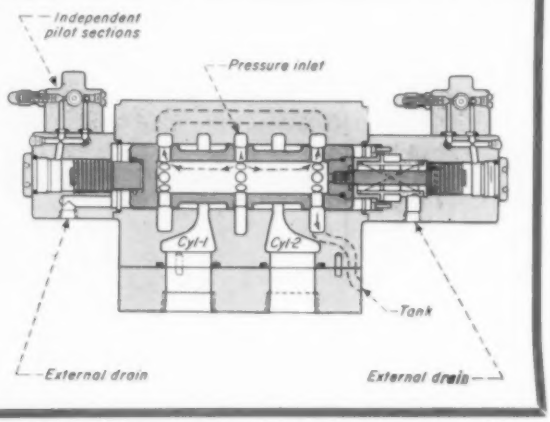


Fig. 7—Pilot-operated spring-centered four-way tandem valves normally are provided with external drains for the spring and pilot sections.

so that there is no tendency for the spool to shift as a result of back pressures generated if the spool is not fully balanced. High-pressure packing usually creates considerable friction on the operating spool.

When solenoid-operated valves are used, they are usually of the solenoid controlled, pilot-operated type that normally has provisions for an external drain of the pilot section, Fig. 7, and spring pockets.

High-Low Circuits

A high-low circuit usually consists of one relatively high-pressure pump of small volume with flow characteristics based on circuit requirements when the machine is either feeding (through some flow control mechanism) or holding work (such as in a clamping operation). In a feeding operation, volume required must provide adequat flow for the fastest feed rate desired with sufficient additional oil to maintain clearance flows through the components under pressure. In a clamping cycle, pump volume would be based on clearance flows only in circuit components.

The high-pressure pump usually feeds directly into the machine circuit, Fig. 8. The low-pressure pump feeds into the machine circuit through an angle check valve. This angle check valve provides a free flow path into the circuit with a minimum of resistance and at the same time prevents a return flow of high-pressure oil back to the low-pressure pump when the pump is unloaded. An unloading valve is connected in the circuit between the outlet of the low-pressure pump and the angle check valve. The unloading valve is closed as long as the pump is in its operating portion of the cycle and the pilot line has not been activated. Outlet of unloading valve is generally connected to reservoir. The pilot connection comes from the high-pressure portion of the circuit beyond the check valve.

In general there is no relief valve on the low-pressure pump. An unloading valve of two possible types serves this function. Simplest unloading valve is controlled by pilot oil whose action against a pilot piston is shown in Fig. 9. Because of the relatively large pilot-pressure differential between full closed and full open, when using unloading valves of this type there should be at

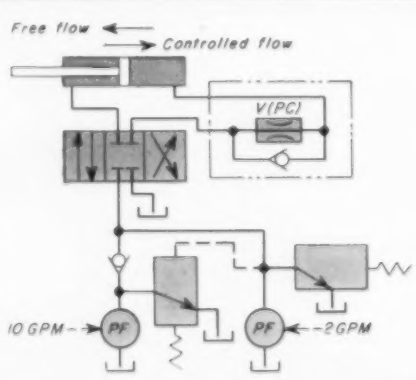


Fig. 8—Typical high-low circuit with two pumps of different pressure-volume characteristics. The high-pressure pump is protected by a relief valve. The low-pressure pump is controlled by a pilot-operated unloading valve.

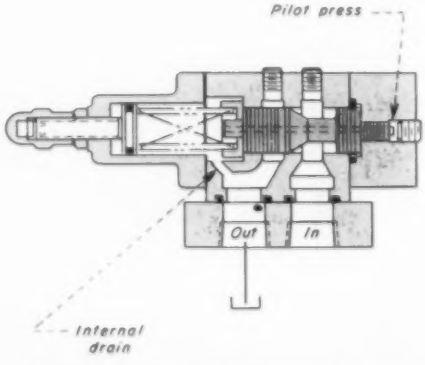


Fig. 9—Pilot-operated unloading valve has pilot pressure directly applied to the pilot piston. A fixed pilot pressure is required to open the valve.

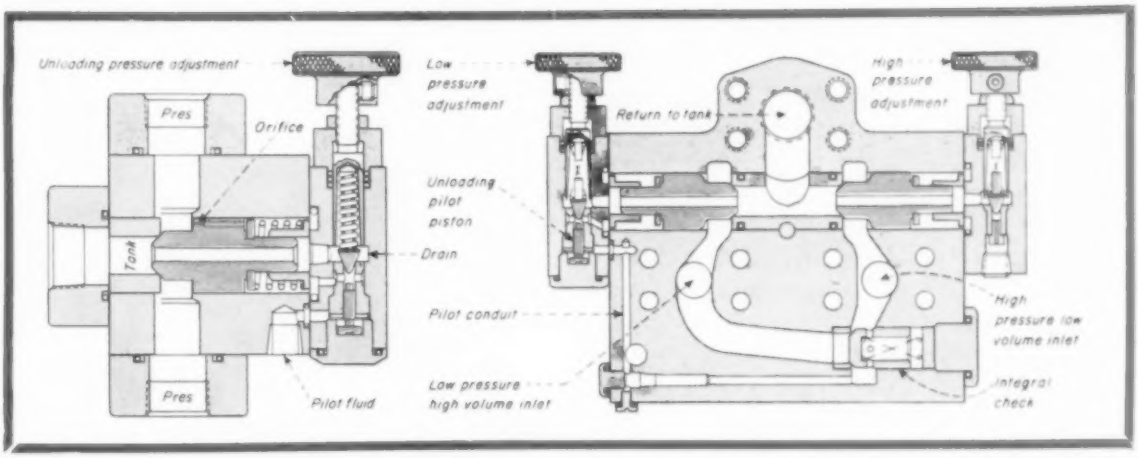


Fig. 10—A more complex pilot-operated unloading valve in which pilot pressure releases oil that has reached the spring pocket through an orifice.

Fig. 11—Valve combination in one housing includes relief valve for high-pressure pump, unloading valve for low-pressure pump, check valve and internal pilot porting.

least 200-psi difference between maximum pressures of the high- and low-pressure pumps.

In later models, the unloading valve takes the form shown in Fig. 10. Here the spring is very light and pressure holding the spool closed comes from the pressure port and leaks through an orifice in the spool to the spring pocket. A tiny relief valve closes off flow between the spring pocket and drain. The relief valve is unseated by pilot pressure on a plunger and more abrupt control of the entire unloading function is made possible. With this type of unloading valve high and low pressures may be set as close as 100 psi.

The direct-acting or pilot-relief types are both actuated by a pressure signal from the high-pressure portion of the circuit. The spring on a direct-acting unloading valve can be adjusted for various physical forces which, in turn, control the value of the pressure required to divert delivery of the high-volume pump back to reservoir. This pilot mechanism is independent of the low-pressure or diversion portion of the two-way spool. With the direct-acting two-way valve the high-pressure section reaches a predetermined pressure value sufficient to lift the two-way spool and the high-volume pump delivery is diverted by this action back to the reservoir at frictional resistance values only. With a piloted-relief-type unloading valve, oil is diverted back to reservoir at a slightly higher pressure setting but insignificantly higher in most installations. The value is established by friction factors plus spring force on the main spool.

Unloading valve, relief valve and check valve may all be separate and individually piped in standard fashion. However, combination valves are available, Fig. 11, including the three valves in one housing and internally ported with consequent better leakage insurance and installation convenience.

Power requirement of this circuit is the sum of low-pressure pump power computed at the point at which the unloading valve becomes fully effective plus the power needed to drive the high-pressure pump to the relief value of the unloading valve. During the high-pressure part of the cycle, power consumption is usually so low that it can be disregarded. This may not be entirely true in gargantuan jobs, but the run of the mill system will follow these general rules.

Power dissipated during a holding action will appear in the form of heat. These losses are unavoidable and can be considered a normal cost of doing business. However, there is no point in making this high-pressure flow any greater than absolutely necessary.

Therefore, the temptation to use high-pressure oil as an addition to the low-pressure pump flow to increase rapid-traverse rate should be resisted. From a first-cost standpoint it may seem desirable to stay in the smallest possible pump-housing series. Thus if 18-gpm rapid-traverse flow is required, and only 2-gpm feed and holding fluid, it may seem logical to use an 11-gpm low-pressure pump and an 8-gpm holding pump. However, power loss to heat in the 8-gpm pump would cause difficulty throughout the life of the machine. It would be far better to pay the higher original cost to buy an 18- or 20-gpm volume pump and a correct 2-gpm holding pump even if there is more oil volume available than necessary and a sacrifice of small size is involved.

For the same reason the unloading valve must be adequate for the flow it must handle. Valve sizing should always be on the plus side. Excessive pressure drop through this valve is a total loss and will create additional power losses and heating problems.

Most circuits in use in industrial applications incorporate sliding spool-type valves which depend on a metal-to-metal fit for sealing between directional control ports. Recognizing that there must be a certain drain loss of the fluid media with this equipment to provide adequate lubrication and provision for thermal expansion, the high-pressure pump is chosen with extra capacity. Excessive wearing of circuit components can, after a period of time, make it necessary to either add more volume capacity to the high pressure pump or repair the circuit component in which excessive loss is occurring. If this is not done, the high-pressure pump may be unable to create sufficient pressure to actuate the unloading valve or valves. This condition makes itself apparent by loss of high operating pressures, ex-

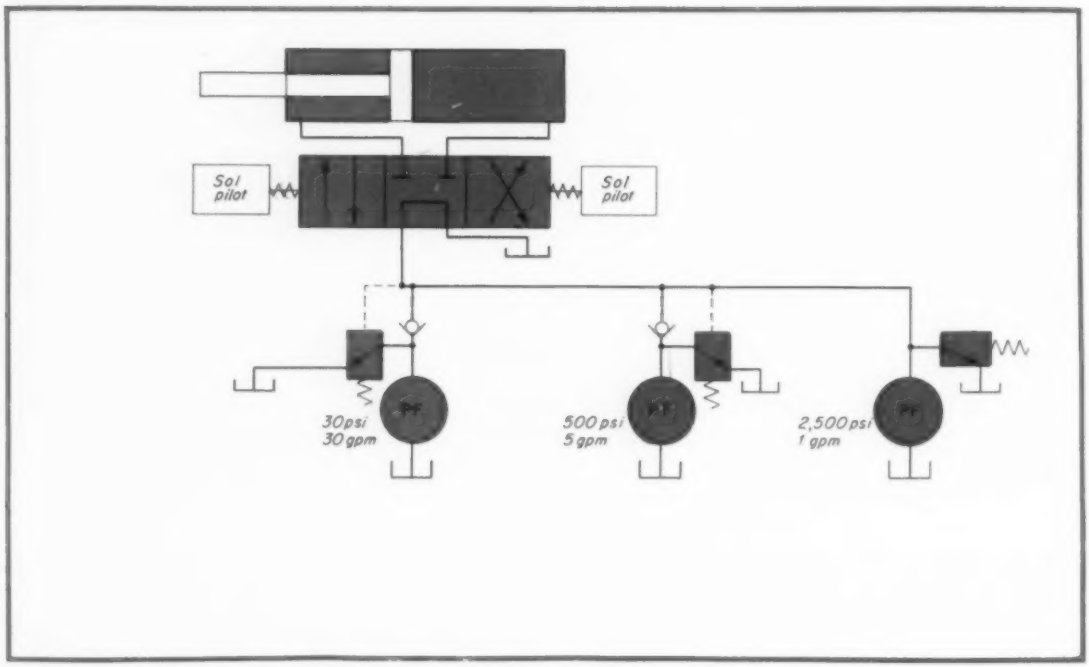


Fig. 12—Three-pump system for three pressure ranges required in a bearing assembly operation. Forward piston speed depends on load resistance, return speed has all pumps acting simultaneously.

cessive heat, and usually higher over-all operating noise level of the power unit.

When circuits require fairly long periods of high-pressure operation but flow is limited to clearance losses in the directional valving a relatively small capacity accumulator may be added. Full charge of the accumulator signals the high-pressure pump to unload so that excess flow is not forced to spill over a relief valve.

In some applications there may be several steps of pressure and volume requirements, as in the circuit of Fig. 12. A machine for inserting bearings into a large housing may require a large volume of fluid to provide sufficient speed to bring the bearing applicator to the inserting point. This may be a 30-gpm pump operating at a maximum pressure of 100 psi. When the bearing is against the bore, a pressure of 300 to 500 psi may be necessary to force it into place, supplied by a 5-gpm pump. During this time the 30-gpm is unloaded because the pilot line opens the valve controlling the unloading cycle on this pump at the 300-psi pressure setting.

After the bearing has been pushed into a portion of the bore at a relatively low speed, a final bore, perhaps of a very close or interference fit, may require a very slow push at 2500 psi. The 5-gpm pump is unloaded when the pressure exceeded 500 psi, and a 1-gpm high-pressure pump completes the operation. Return stroke, as well as initial rapid traverse, would be with all three pump flows, or a total of 36 gpm. Variations of this circuit are widely used in all types of industrial applications.

In many installations a high-volume, low-pressure pump is used in conjunction with a relatively low-volume variable-delivery pump. An unloading valve controls maximum pressure of the low-pressure pump. Any further rise in pressure will automatically reduce delivery of high-pressure pump until a certain minimum value is reached. This minimum is often just sufficient to make up for clearance flows at maximum pressure value in the circuit.

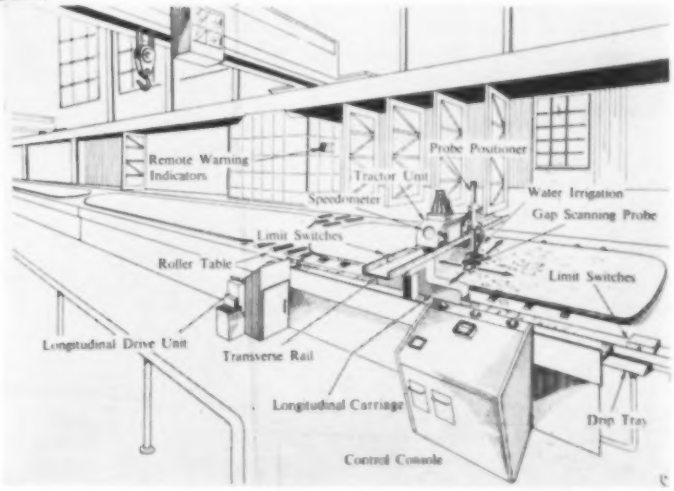
A small-capacity, variable-delivery pump will often introduce further economies in the circuit design of the high-low type by avoiding the necessity of passing oil over a relief valve at the maximum value. The economic factors involved in each particular circuit will dictate the correct combination. High pressure oil delivered by a variable delivery pump is tailored to instantaneous circuit needs and will vary to suit the condition of components.

This is the last in a series of articles covering the function and application of hydraulic control valves to typical circuits. Earlier articles covered: Relief Valves, December 1956, page 174, Pressure Control Valves, January 1957, page 196, Flow Control Valves, March 1957, page 144, and Directional Valves, May 1957, page 167. Throughout this series, emphasis has been placed on internal construction differences and the operational peculiarities resulting therefrom. Information of this type is not available from standard textbooks but is the synthesis of actual experience in the design and application of valves in industry.

TECHNICAL NEWS

◀ OPERATOR IS SETTING UP gap testing device for continuous testing of steel plate. Note two flexible tubes which irrigate the surface to make "contact" between the probe and plate. Frequency range is from 0.5 to 10 Mc/5, with frequencies up to 25 Mc/s available on special order.

IN A STEEL PLATE MILL a continuously irrigated probe head incorporating a marking unit makes a complete search over the plate's area. It detects the presence of laminations, records the information on a plan position recorder and simultaneously marks the plate. The automatic monitoring and flaw alarms are adjustable from 1/10 in. below the top surface to 25 ft both in location and width. ▼



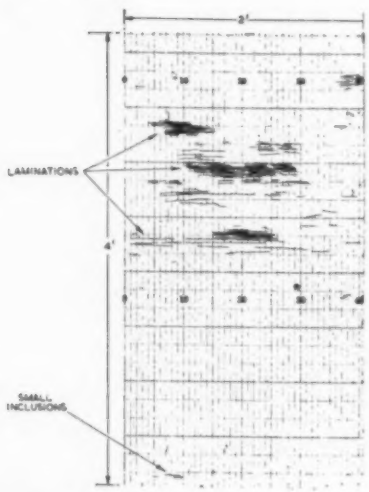
Ultrasonic Tester Joins Production Line

Autosonics, a trade name adopted for a new technique of automatic ultrasonic non-destructive testing developed by Kelvin & Hughes, Ltd., 2 Caxton St., London, S.W. 1, England, reportedly tests material at a rate of speed greater than that of existing techniques. An inspection speed of 100 ft per min will pick up defects of $\frac{1}{8}$ in., while gross defects are picked up at a scanning speed of 400 ft per min. Possible application is in a steel plate mill. Permanent records also are made from the test for future reference.

The method consists of the well known pulse echo system of inspection which uses a high frequency sound beam to detect flaws and discontinuities in the material being tested. An inspection probe which makes its contact with the material by a liquid, transmits the sound into the material as a sequence of energy pulses. When the pulses reach the opposite face they are reflected back to the probe, the time required being dependent upon the velocity of sound in the material and its thickness. These events are displayed as a trace on a cathode ray tube.

Gap testing is the procedure used with the high speed testing apparatus. A very small distance is maintained between the probe and specimen, and is filled with liquid by a continuous irrigation system. This is opposed to immersion testing where a large distance is maintained between the probe and specimen, both of which are immersed in a tank of liquid.

The automatic flaw alarm and recorder section of the system can be adjusted to respond to indications from defect signals in any sections, or only to signals from separate narrow



A PLAN POSITION indication recording taken from a steel plate 4 ft x 2 ft x 1 in. showing the plan position of areas of laminations and small inclusions. The entire electronic system consists of a flaw detector section; an automatic gain control section; an automatic flaw alarm and recorder section; and a system fault alarm section.

strata which can be set anywhere in the cross-section. Sensitivity can be adjusted so that it will respond to small or large flaws, and ignoring those which are less than the pre-set level. The output from this section can be used to operate various recording systems, for example, to provide a plan position indication of any defects present in a plate.

This continuous testing forms part of the production line, with a continuous inspection of strip for laminar type defects. Inspection range is up to 25 f.

Transistors Operate at 850F

New semiconductor compounds, particularly gallium arsenide, are replacing the conventional germanium and silicon to make possible operation over a broad range of frequencies at 850F. Successful tests of this nature have been made at RCA's David Sarnoff Research Center in Princeton, N. J. The work is leading into exploratory research that might well produce compounds capable of operating efficiently at perhaps several hundred degrees higher. Also, gallium arsenide solar battery cells have shown good performance in laboratory tests.

The Growth of Industrial Electronics

Industrial electronics—that is, electronic control instruments and apparatus to gather and use information—has matured from a promising prodigy with sales of $250 million in 1948 to a robust business with sales of $700 million in 1955. The variety of current applications and those under development make it apparent that "there is no industry now known that cannot profit from the use of electronic techniques." This confidence in the almost endless frontier for industrial electronics was voiced by Ellsworth D. Cook at the recent Conference on Industrial Electronics in Chicago. Industrial electronics is the fastest growing segment of the electronics industry which also embraces radio, TV, and military apparatus. Industrial electronics has grown up enough now to require designing of special components to fit the special requirements of industrial apparatus. Earlier designs used the same components as other branches of the industry.

Cook further anchors his optimism in a combination of economic and technical realities now affecting industry. Pressure to cut production costs in order to increase profit margins are intense. That means that industry is driving constantly to speed up production, cut waste and the amount of rework, cut production manhours, and control any of the other variables that boost costs. But in many cases, industry is reaching "natural limitations" on how much it can improve speed and accuracy on the basis of present technology. Growth of post war industrial capacity has come about in part by design of mammoth new production machines and development of new methods. But the growth in capacity represents more than simply larger and more efficient versions of machinery. It includes also applications of revolutionary new electronic devices that have broken through some of the "natural limitations" to production. As Mr. Cook expresses it: electronics is "filling a fundamental need for an advance of a more technical nature wherein the use of new scientific discoveries give more than merely additive gains."

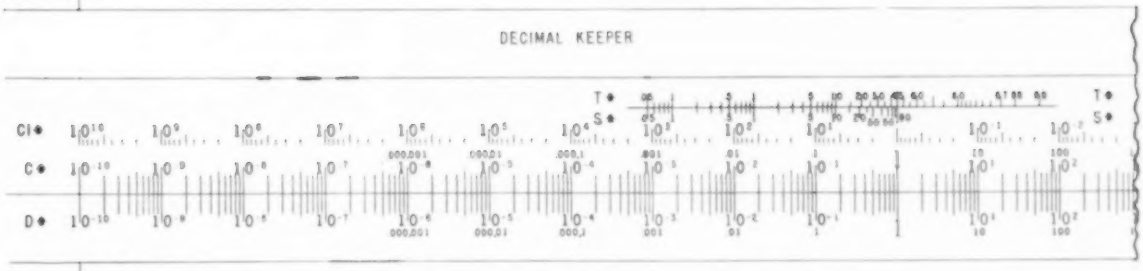
Mr. Cook cited a number of cases in which electronic apparatus has been the means to overcome a serious limitation on the efficiency and rate of output in heavy industry.

Prior to electronics, steel mills had no means of measuring the thickness of steel sheet in a hot strip mill since it was impossible to use a device that made contact with the hot sheet. And in a cold strip mill where a use of contact device was possible, measurement was feasible only if the sheet rolled at no more than 3000 feet per minute. Development of an X-ray thickness gage now makes it possible to get exact knowledge of the thickness of the strip without marking the product. And the mills have been able to speed up production: hot strip mills because they no longer need to cool the sheet before measuring it, and cold strip mills because the sheet can be rolled as fast as 7000 fpm.

Electronic exciters are replacing rotating d-c exciters in power generation. Exciters today have output of from 0.3 to 0.4% of generator rating. And the power involved runs to 750 kw for today's large generators, and 2000 kw for models under contemplation. Incentives are strong therefore to use an electronic exciter in preference to a rotating machine.

In mining taconite a substantial saving has been achieved by developing an electronic device to detect tramp metal, such as stray drill bits, bolts from machinery and other objects that get mixed in with the crushed ore. Tramp metal is a hazard to crusher linings and can break the drive shafts. The damage that results means not only high maintenance costs but also a slow-down in production when a crusher is thrown out of order.

Already electronics engineers are hard-pressed to design special equipment to perform an almost endless list of special industrial jobs. These run the gamut from equipment designed to read print to equipment that can analyze the moisture in a chemical process, measure the exact amount of carbon required to assure pelletization of iron ore in the benefication process, perform clerical operations to avoid human errors, detect flaws in rotating machines or any other machinery that constitute a safety hazard.



Slide Rule Keeps Track of Decimal Point

The wandering decimal point problem connected with slide rule computations has been solved with a "decimal keeper" slide rule which locates the decimal point without pencil and paper or mental calculations. For less precise work it computes directly without loss of the decimal point. Slide rules with decimal keeper scales in addition to conventional scales are manufactured by Pickett & Eckel Inc., 1109 South Fremont Ave., Alhambra, Calif., under license from L. J. Kamm.

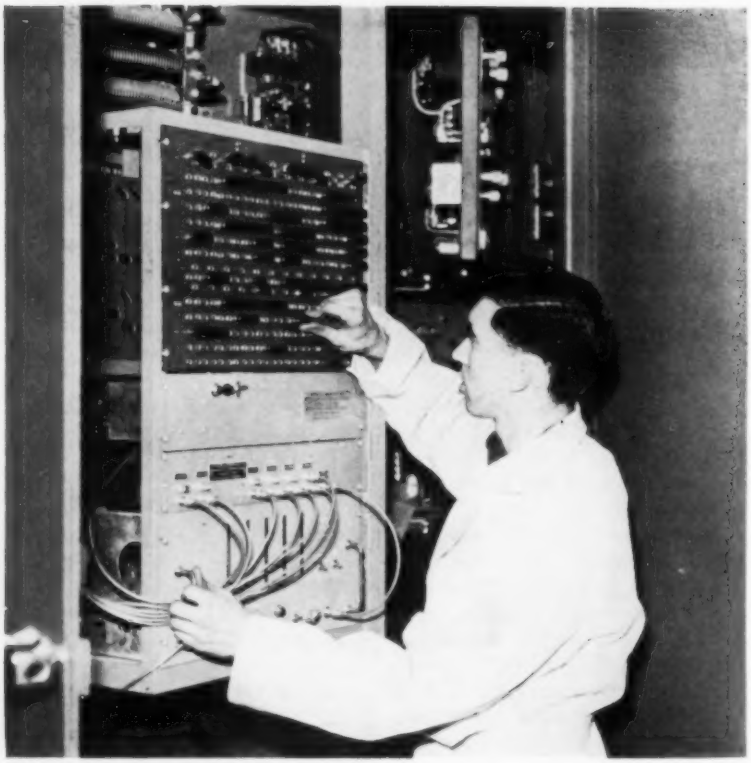
As shown in a partial view of the slide rule above (model 904), the C* (c star and D* scales have every number from 10^{-10} through 1, to 10^{10} with its own position. In use, the problem is first worked on the decimal keeper scales, giving the answer to between one and two significant figures with the decimal point in place. If three figure accuracy is required, the problem is re-run on the conventional scales on the other side of the rule.

Besides the C* and D* scales, there are the CI*, S*, and T* scales having the same relationship to C* and D* that CI, S and T and to C and D. S* and T* extend several decades and cover the range from 0.05 deg to 89 deg on one continuous scale. This presents a wider range of values, and makes it unnecessary to use complementary angles for tangents beyond 45 deg.

The C*, D*, and CI* are multiple logarithmic scales, each drawn 1/20 the length of C, D and CI. Doubling labeling of the scales simplifies use. The same point is marked 100 and 10^2.

The written out form is stopped beyond 0.000001 and beyond 100,000 because of space limitations, and because this form is not much used beyond these points. The exponential form is shown throughout. No folded scales, corresponding to CF, DF and CIF are provided, since scale overhang rarely occurs.

A HOLLOW AXLE which will take 16 times more torque than a regular axle, also is the major part of General Motors Corp's new air suspension system. Basic apparatus includes a hollow axle, 6 in. in dia, containing 1000 cu in. of air linked to two rubberized air bellows. This type of linkage permits a free flow of air between the axles and bellows. Heavy road jolts and high-frequency vibrations are absorbed before they reach the frame. GM says its axle can withstand 16 times more twisting force than a regular type. And steel walls 5/16 in. thick give an 11,000 lb load rating. Air pressure in the system reaches 100 lb when the vehicle is carrying full load and drops to 65 lb when it is empty. The new suspension is expected to offer a good economic advantage to the trucking industry, as trailer cubage can be increased 3 to 8% because the fifth wheel on the tractor has been lowered through the use of the air suspension system.



NEW TYPE TEST STAND can check many different types and models of fuel controls simply by changes in the diode patchboard.

Fuel Control Stand Saves Test Time

Two developments of an automative nature as applied to the testing of jet engine fuel control on test stands have resulted in a saving of more than 30 percent in time, it was reported by the George L. Nankervis Company of Detroit, Mich.

The first development provides for automatic programming of certain operations of the fuel control on the test stand to specified requirements. The second allows for an automatic data recording system that shows graphically during testing the operating performance of the fuel control unit.

Previously, the operator of the test stand had to mount the control unit, manually accelerate and decelerate the control throughout its entire test run. The operator had also to make recordings of data at predetermined points —as many as 178 points—at which times he'd have to stop the test run.

After the test was completed, the operator would then have to draw a graph from the readings obtained, and if any portion of the test curve was out of limits he'd have to make the necessary adjustments.

With the new Nankervis test stand, acceleration and deceleration rates are pre-set with the press of a button starting the test. As the performance curve is drawn, the operator can see immedialy where adjustments have to be made, stopping the test to do so, rather than having to wait until the end of the test.

The recording system unit includes an x-y plotter enabling the operator to select and amplify critical portions of the performance curve.

On the Nankervis test stand, the fuel control (driven by a 125 hp variable speed motor) and the fuel pump (driven by a 5 hp variable speed electric motor both held to an accuracy of 0.25 percent) are interdependently driven and by the use of electrically inter-locked circuitry the two motors can be coordinated to maintain pre-set speed relationships.

News Briefs . . .

A scarcity of trained personnel, not a shortage of technical knowledge, is slowing Britain's efforts to create a nuclear power industry, it was argued recently by a prominent English engineer. Defending Britain's plans for rapid development of peacetime atomic power as contrasted with America's more studied approach, W. R. Wooton, of Babcock & Wilcox Ltd., London, said that plants of the current British type are simpler, and safer, and will still be built 25 years from now. He contended also that educational programs keyed to nuclear engineering and reactor technology are being applied through England in an effort to relieve the shortage of trained engineers and scientists.

West Germany, little more than a decade ago a battered region of a completely defeated Germany, last year increased its share of the world's machinery export market to 19.9%, or 1.4 billion dollars. This advance, representing a 21.1% increase over 1955, enabled West Germany to outrank Great Britain in total machinery exports for the first time in the post World War II era. Great Britain's share of this export market dropped from 19.6% in 1955 to 18.1% in 1956. First place in machinery exports is still held by the U. S. West German delivery times have improved, averaging seven months compared to 7.5 months a year before. This latter results from expansion of production facilities enabling this West German industry to increase production during 1956 by 15%.

Lightweight shielding against the effects of nuclear radiation will be just one of many needs of the aircraft industry by 1967, according to a survey report issued by the Aircraft Industries Association's Aircraft Research Committee. This committee predicted the industry's needs on the basis of expected advances in the fields of aircraft materials, processes and high-temperature testing. The committee expects that airframe temperatures may reach temperatures of as high as 3500 F and that thermal difficulties will result from ever-increasing flight speeds. In the metallic ma-

terials field, it will be necessary to extend and evaluate the physical properties of aluminum to 500 F, of magnesium to 800 F, of titanium to 1200 F, and of steel alloys and specialty steels to 1200 F, in wrought, forged and cast forms. Porous metallics for skin cooling will also be needed. The committee predicted a critical need for transparent laminated plastics capable of withstanding 500 F, and that all plastics within 10 yr should be capable of withstanding 800 F. Also, almost certain to be needed will be better refrigeration units, engines, fuels and electrical equipment.

The shortage of engineering manpower may well be relieved by encouraging more women to become engineers. These are the sentiments of Emma C. Barth, herself an engineer employed in the East Pittsburgh, Pa., plant of Westinghouse. In a speech to Pittsburgh educators, Miss Barth pointed out that of 120,000 college degrees earned by American women in 1956, only 62 were for engineering. Miss Barth charged that prejudice and misunderstanding on the part of educators as well as industrial management prevents many women with natural engineering aptitudes from entering the field. She said that the idea that women do not have what it takes to be engineers is belied by the fact that a U. S. Labor Department report shows that the male advantage over women in basic aptitude tests was a mere 3 to 2. Miss Barth's professional work has been concentrated in the field of turbine generators.

Cases of the engineering professor being lured from the campus to industry by higher salaries are legion. But at least one academic engineer has chosen to stay on campus. He is Brooklyn Polytechnic Institute's Charles A. Hachemeister, professor of electrical engineering. Professor Hachemeister's letter of refusal released by Brooklyn Poly and reprinted in a recent Engineering and Scientific Manpower Commission Newsletter offers the suggestion that industry may be doing itself more harm than good by raiding the teaching staffs of the engineering schools. The letter reads in part: "I am indeed flattered by your considering me capable of filling one of the close-to-the-top positions in new research and development projects. It is a well established fact that the monetary remuneration of industry greatly exceeds that of teaching. However, we must remember that industry needs and will continue to need young college trained engineers. If all the college staffs were depleted because they were attracted to industry by the higher salaries, the colleges would cease to exist. It seems to me that industry would be serving itself and our nation better if, . . . it would strengthen our schools so more and better engineers may be trained. The obvious and most practical way for industry to strengthen the schools is to funnel some funds to the schools so that capable people will be able to afford to teach and will have adequate equipment to perform research."

A new type landing gear for heavy Air Force cargo planes with a gross weight close to 100,000 lb has been developed by Lockheed Aircraft Corp. Instead of the conventional arrangement, the new design consists of two wheels, placed on both sides of the plane, one in front of the other. This tanden arrangement offers several advantages over conventional gear: greater reliability, less concentration of weight on runway, and narrower housing for wheels when retracted. For military planes that must land on soft airstrips, a rear wheel that follows in the track of the front wheel reduces friction.

The recently created Foundation for Instrumentation Education and Research has added four members to its Board of Trustees. They are Dr. Gordon S. Brown, Head of the Electrical Engineering Department, Massachusetts Institute of Technology, Woodrow W. Garey, Publisher of CONTROL ENGINEERING magazine, McGraw-Hill Publishing Company, Dr. Cuthbert C. Hurd, Director of Automation Research, International Business Machines Corp.; and Dr. Augustus B. Kinzel, Vice President–Research, Union Carbide Corp. The foundation, a non-profit philanthropic agency, was set up to sponsor educational projects and basic research in the engineering-science of instrumation and automatic control, or automation. Current projects include administration fellowships for basic research in various phases of automation technology.

Rapid Response Thermometer

A quick response thermometer which can sense a temperature change less than one-millionth of a second after it occurs has been developed by Cornell Aeronautical Laboratories in Buffalo, N. Y.

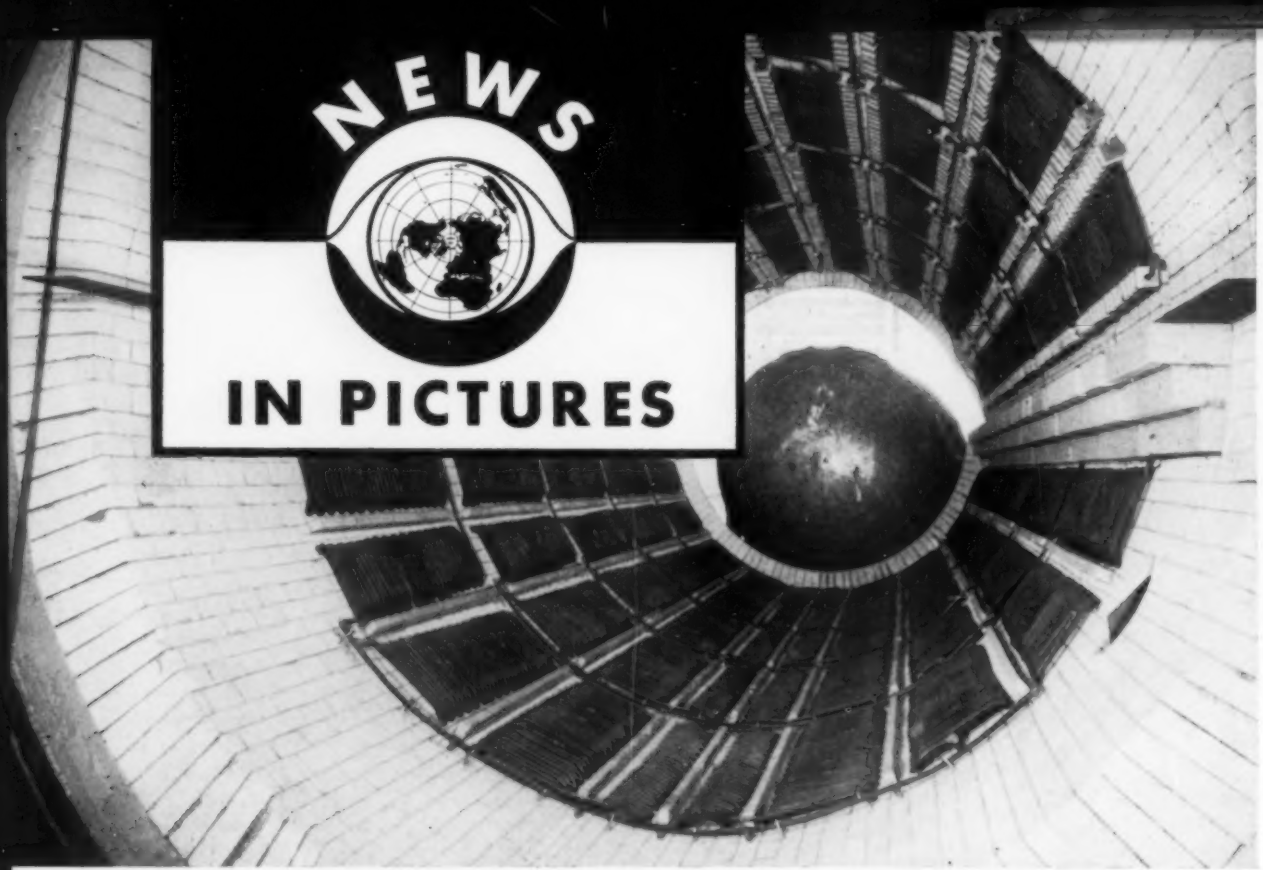
Specific use for this thermometer–conventional types lag 10-30 seconds behind this fast-acting thermometer–has been applied to measuring temperatures on aircraft and missile models undergoing tests in the Laboratory's 10,000 mph hypersonic shock tunnel. A test run in this tunnel is completed in about 1/1000th of a second.

Robert Vidal, CAL engineer who designed the quick response thermometer, reported that the University of Florida has used it to measure temperatures in jet engine inlets. He suggested that it may prove valuable in automobile engine research.

A platinum sensing agent consisting

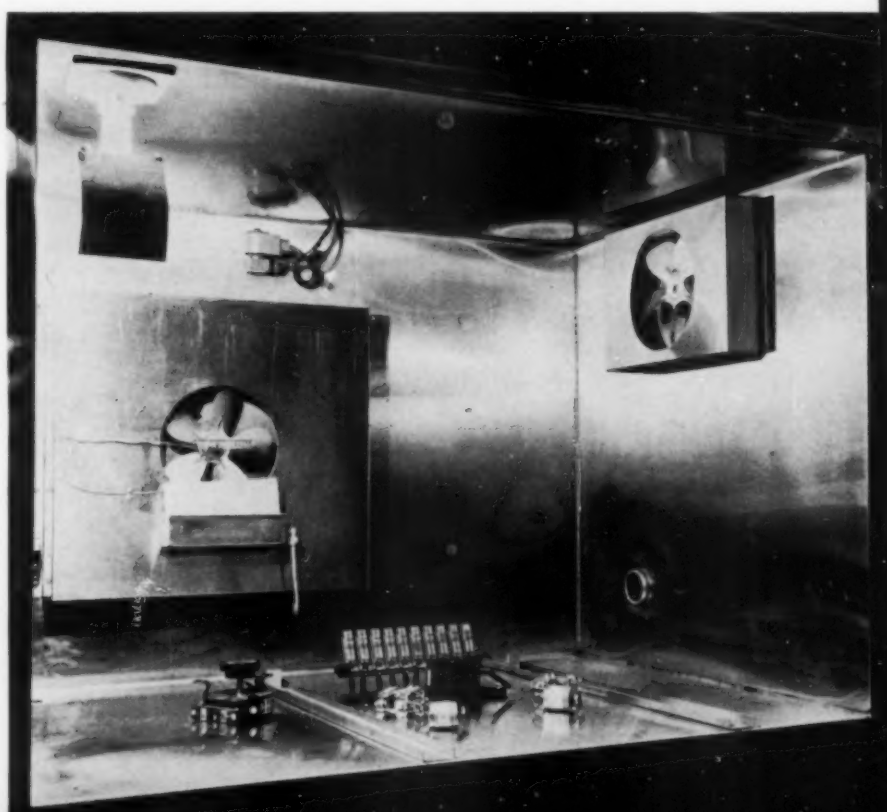
of a film of platinum–only 4/millionths of an inch thick and printed on a glass plate–is the heart of the CAL thermometer. This film is so thin it picks up or loses heat almost as instantly as surrounding temperatures vary; the electrical resistance of the platinum correspondingly increasing or decreasing.

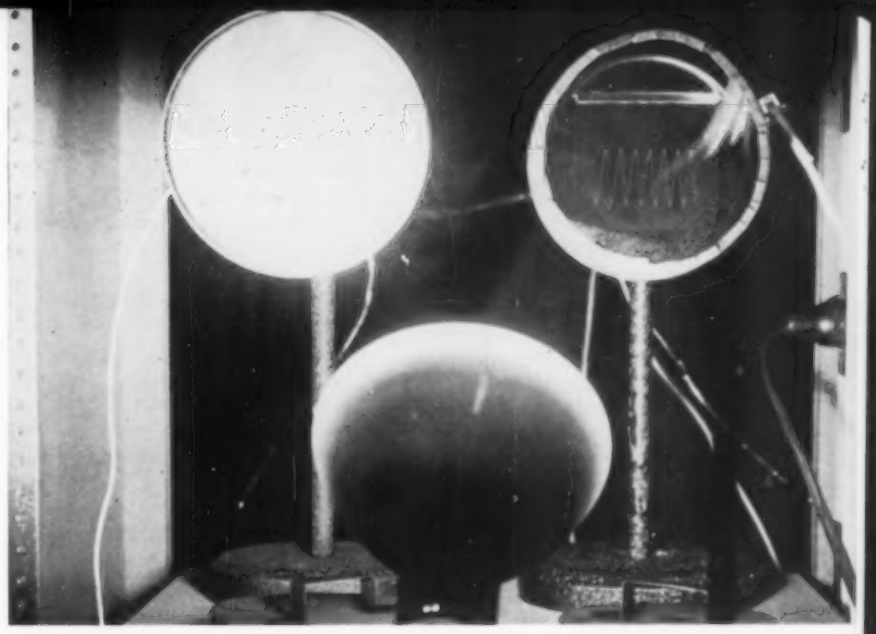
NEWS IN PICTURES



TEMPERATURES UP TO 2100 F and vacuum down to 0.3 microns are possible with this heat treating vacuum furnace—said to be the world's largest—now being used at North American Aviation's Missile Development Div., in Downey, Calif. Designed by the Lindbergh Engineering Co. of Chicago, full-size flat sheets of titanium can be wheeled into the furnace, which is over 40 ft long, with a work chamber 14 ft in length and 6 ft in diameter. The furnaces use 820 kw. In addition it will be used for brazing sheet metal honeycomb. An internal tube cooling system has been built into the furnace for setting the braze before moving the treated metal into the cooling chamber.

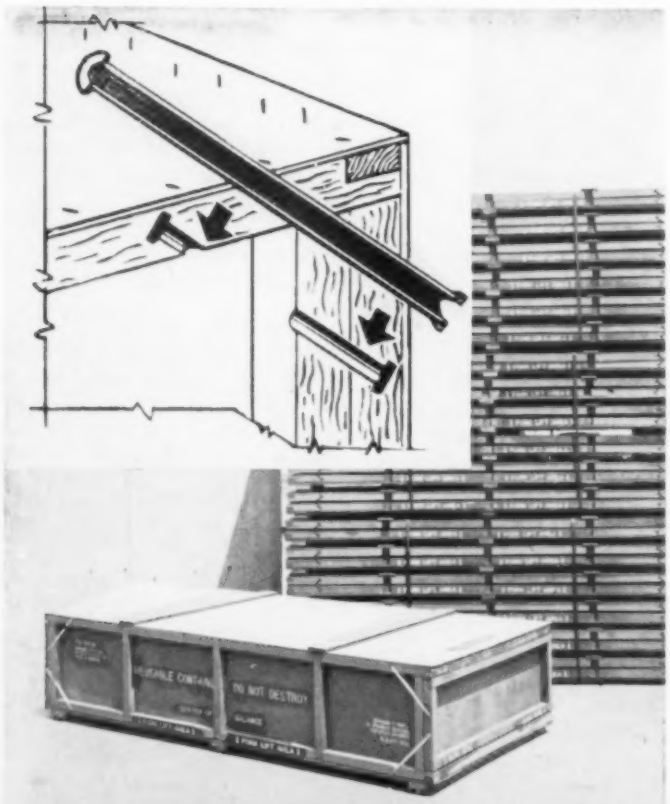
ENVIRONMENTAL TEST CHAMBERS ranging in size from 1 cu ft to walk-in rooms have been designed by the Associated Testing Laboratories, Caldwell, N. J., using a novel refrigeration system. The system has no compressor, condenser, or heat exchanger, and actually no moving parts except one valve. Cooling is produced directly by the vaporization of liquified CO_2 or other gas released into the refrigerated area through the control valve. According to the company, this gives efficient and rapid cooling, close temperature control, and economical operation. With the 32 cu ft test chamber, it is possible to go from room temperature to —100 F within 5 min, compared with the 1½-4 hr for mechanically refrigerated eqeuipment, according to the company. In the chamber above, the vaporized CO_2 or other liquid gas is injected through the valve above the open top of the fan housing. The strip heaters are behind the fan housing, and the dry-and-wet temperature sensing bulbs (coiled) are located in front of the suction fan. The cost of the complete test chamber is reported to be about ¼ that of conventional cabinets of comparable capacity, and operating costs 50% less.





SHOWN DURING A TEST at the Naval Research Laboratory in Washington, D. C., is a new daylight television tube (right) compared with the conventional tube on left. Although the pattern is displayed on both tubes, the pattern on the conventional tube is completely obliterated. The pattern on the new tube can be seen in spite of the bright light shinning on it. The new tube will permit the viewing of television in bright daylight with little loss in contrast, and is reported to offer a new simplified approach to color television.

BELL TELEPHONE LABORATORIES' "LEPRECHAUN," a high-speed digital computer not much larger than a television set, has flexibility as its feature, permitting it to be used as a test model for research on digital computers for military applications. Proposed new designs can be heated on the Leprechaun without building new equipment. With its random-access magnetic core memory, the machine can take its instructions immediately from the memory, regardless of where the necessary instruction is stored. This differs from that of computeds having a revolving drum memory. Storage capacity is 1024 words. The major factor in the reduction in size and power consumption is the introduction of direct-coupled transistor logic (DCTL) circuitry.



THE LATEST THING in industrial shipping containers uses no nails in assembly, can be shipped and stored knocked down, has interchangeable parts to make different size containers with fewer panels, can be assembled or disassembled in 1-2 min, has greater structural strength while using fewer structural members than other type boxes. The new container is made by the Evans Container Corp., 5832 E. 61st St., Los Angeles 22, Calif., and has 45 deg diagonal bracing as a built-in feature. This brace is a tubular metal spindle which fits into slots designed into the eight corners of each container. One staple into the cleat across each end of the metal looking spindle will lock the box, also making it reusable without losing any of the original structural strength.

TECHNICAL NEWS

In Materials . . .

New Advance in Titanium Manufacture

Titanium tetrachloride, a compound necessary in the manufacture of titanium, now can be made at temperatures much lower than those required for the present method, according to an announcement from the Armour Research Foundation of Illinois Institute of Technology, Chicago 16, Ill. In addition, the compound is produced with a higher purity and at less cost. Armour also reports that the process will permit the use of low grade ores, such as ileminite, in the manufacture of titanium. While it will take some time to develop the process fully, it is expected that it eventually will replace the high temperature process now in use.

Tough Plastic Molding Powder

A modified acrylic molding powder called Implex is reported to have a considerably greater toughness and impact strength, combined with the general stability characteristics of acrylics, and at a price in the range of medium-cost molding materials (presently available in limited quantities at $.56 per lb). Made by Rohm & Haas Co., Philadelphia 5, Pa., the new powder has no plasticizers, has low water absorption, and is easily machined and cemented. The company's field evaluation program showed the plastic powder to be particularly suitable for such applications as: shoe heels, business machine keys, knobs, valve parts, pen and pencil parts. Other characteristics are: specific gravity, 1.12; tensile strength, max, 5200 psi; modulus of elasticity, 220,000 psi; elongation at break, 30%; flexural strength, max, 8000 psi, modulus of elasticity, 235,000 psi; impact strength, Charpy unnotched at 73 F, 30 ft-lb; water absorption, 24 hr immersion at 73 F, 0.3 per cent.

High Purity Metals

The toughest metals known are not too far away from industry-wide production with the announcement by three companies that a new furnace, which pioneered in titanium melting, is being made available to the metals industry. Called a consumable electrode vacuum remelting furnace, it melts titanium, zirconium, high alloy steels, and other ferrous or nonferrous alloys which are free of impurities. The three companies, Titanium Metals Corp. of America, Allegheny Ludlum Steel Corp., and Lectromelt Furnace Div., of McGraw-Edison, claim that "the process will open new markets, some now clearly defined and others in fields where much exploratory work. Now all the refractory metals and many precision superalloys can be production melted into large, homogeneous ingots at great speed and relatively low cost." Lectromelt will manufacture and sell the new furnace.

How to Save Nickel and Chromium

Less nickel and chromium will be used in jet engines as the result of a research project sponsored by the Manufacturing Methods Branch of the Air Materiel Command, Wright-Patterson Air Force Base, and the Continental Aviation and Engineering Co., Detroit, Mich. Critical materials eliminated amounted to 44.7 lb of nickel and 17 lb of chromium in the Palouste 140 Air Compressor. Key to the savings program was the use of nicrobrazing and ceramic coating techniques on noncritical material used for turbine bolts, pressure force balancing disks, turbine inlet nozzle shrouds and vanes, and inner and outer combustion chamber liners. For nickel steels, such as Nimonic 75, a 310 grade stainless steel was substituted. Ceramic coating was applied to the 321 grade stainless, and 321 and 310 stainless steel sand and precision castings were substituted for a 321 grade stainless steel forging. Continental is using the same technique on the production of blades for their J-69 jet engine.

High Rotary Speed Aluminum

A precision cast aluminum alloy impeller whirled at a peripheral velocity of 2000 mph in tests made at Alcoa's Cleveland plant to determine the possibility of using new aluminum alloys for high speed rotating parts. In some tests the impeller is rotated to destruction. In others, the impeller is covered with a brittle lacquer substance, and after spinning at speeds just short of destruction, the cracks in the coating show proof of the high stress areas. Most of the investigation has been conducted with aluminum alloys made by processes using sand, permanent mold, semi-permanent mold, plaster, and die casting.

New Reactor Research

Argonne National Laboratory's plans for expansion of its nuclear power and research and development activities include: (1) An Experimental Breeder Reactor, EBR-II, which will develop 62,500 kw of heat and 20,000 kw of electricity. This compares with EBR-I, which developed only 1400 kw of heat and 200 kw of electricity. The breeder reactor produces more fissionable than is burned up in the reactor. (2) The Argonne Low Power Reactor, which is being made for the Dept. of Defense. The design of this package-type reactor will give technical data for civilian power reactors. (3) A Transient Reactor Testing Facility, which will offer American scientists their first chance to destructively test fuel elements for breeder type reactors, and under conditions that might occur in an accident. (4) The Argonne Boiling Reactor, a full-scale reactor, the purpose of which will be to investigate boiling water reactors developing pressures up to 2000 psi and 400,000 kw of heat.

Sawdust and Radioactive Waste

A promising development in the atomic energy field comes from the CEAN Laboratory at Mol, Belgium. This principle government agency, the Study Center for the Application of Nuclear Energy has found that sawdust is an effective absorbent in the decontamination of radioactive water. This is expected to simplify handling and reduce disposal costs. The absorption capacity of sawdust is almost the same as that of clay or vermiculite, and it can be increased considerably by rotting. The other column characteristics are good.

COMING EVENTS

AUGUST 11-15

First National Conference on Applied Heat Transfer, Pennsylvania State University, University Park, Pa. Sponsored by the Heat Transfer Div. and the Central Pennsylvania Section of the ASME. The theme will be Applied Heat Transfer, and papers are being solicited which bear directly upon heat transfer applications. Particularly sought are papers dealing with the design, construction and use of heat exchangers, economic and practical problems associated with insulation, methods of instrumentation and tests, and the results of research which may be applied in industrial practice.

AUGUST 20-23

Western Electronic Show and Convention (Wescon), Cow Palace, San Francisco, Calif. More than 200 papers will be scheduled under general headings including: automatic control; circuit theory; component parts; electronic devices; electronic computers; engineering management; industrial electronics; instrumentation; military electronics; nuclear science; reliability and quality control; and telemetry and remote control.

AUGUST 26-28

1957 Gas Dynamics Symposium, at the Technological Institute, of Northwestern University, Evanston, Ill. The theme will be "Transport Properties in Gases at High Temperature and Pressures." One object will be to defined the art in both theory and experiment for the determination of the transport properties of gases, with particular reference to extreme conditions. Present and future needs for data with respect to application and design will be indicated. For further information contact Dr. Ali B. Cambel, Gas Dynamics Lab., Northwestern Univ., Evanston, Ill.

SEPTEMBER 4-6

Special Technical Conference on Magnetic Amplifiers, Penn Sheraton Hotel, Pittsburgh, Pa. There will be five technical papers on "New Circuits and Techniques," twelve papers on "Analysis and Design," and six papers on "Applications."

SEPTEMBER 9-13

12th Annual Instrument & Automation Conference, Cleveland Public Auditorium, Cleveland, Ohio.

SEPTEMBER 9-13

3rd Annual Titanium Lecture Program, New York University, College of Engineering. Attendance is limited. For further information write to Dr. Harold Margolin, New York Univ., Univ. Heights, 53, New York, N. Y.

SEPTEMBER 24-25

6th Annual Industrial Electronics Symposium, Morrison Hotel, Chicago, Ill. Major subjects will be: Development of Transducers and Other Elements of Industrial Electronics Systems, and Integrated Systems for Industrial Electronic Control. Inquiries should be sent to E. A. Roberts, Union Thermoelectric Corp., 2001 Greenleaf St., Evanston, Ill.

OCTOBER 10-11

National Noise Abatement Symposium, Hotel Sherman, Chicago, Ill.

OCTOBER 13-17

Annual Pressed Metal Institute, Castle Harbor, Bermuda.

OCTOBER 14-18

International Industrial Development Conference, Fairmont Hotel, San Francisco, Calif. The central theme—industrial development—covers both large and small scale industry and includes both domestic and international capital.

OCTOBER 16-18

11th Annual Conference, New England Sections of the American Society for Quality Control, at the Hotel Stratfield in Bridgeport, Conn. Quality control relating to aerial operations will be stressed.

OCTOBER 17-18

National Conference on Industrial Hydraulics, Hotel Sherman, Chicago, Ill. The meeting is sponsored by the Armour Research Foundation and the Illinois Institute of Technology.

OCTOBER 17-18

1957 Annual Convention of the Magnesium Association, Biltmore Hotel, New York, N. Y.

OCTOBER 23-24

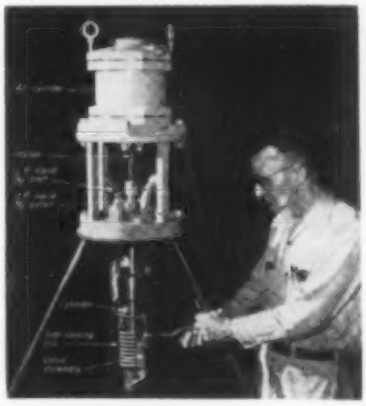
Computer Applications Symposium, sponsored by the Armour Research Foundation, at the Hotel Sherman, Chicago, Ill.

OCTOBER 24-25

14th Annual Display of Aviation Electrical Equipment conducted by the Aircraft Electrical Society in the Pan Pacific Auditorium in Los Angeles, Calif. More than 200 electrical equipment manufacturers will display and demonstrate their latest products.

OCTOBER 31-NOVEMBER 1

3rd Annual Technical Conference of the Professional Group on Electron Devices, Institute of Radio Engineers, at Washington, D. C. The agenda will include the presentation of technical papers covering developmental techniques and devices such as electron tubes and transistors rather than basic research or circuit applications.



Correction

The Technical News section of *Product Engineering* for May carried a story about a 10,000 psi liquid nitrogen pump (above) which supplies nitrogen gas for rocket engine operation. Through an oversight, the name of the designer was omitted. It is: Arthur D. Little, Inc., 30 Memorial Drive, Cambridge 42, Mass.

A MESSAGE TO AMERICAN INDUSTRY • ONE OF A SERIES

What Research Means to American Business

American industry plans to invest $150 billion in new plant and equipment during the next four years—more than in the five years 1952-1956. It plans to carry out this record investment even though manufacturing capacity has nearly doubled since World War II. These facts are reported in McGraw-Hill's tenth annual survey of Business' Plans for New Plants and Equipment. They contradict many long-established theories about investment in capital goods.

According to the textbooks, a high and rising level of capital investment is generally followed by a decline. The bigger the rise—so the old theory goes—the bigger the decline will be. But, after a decade of high-level investment and an especially strong rise in the past two years, industry now has plans to keep right on with near-record outlays for plant and equipment. Does this mean some new factor has been added, to change the investment cycle?

The New Factor—Research

The latest McGraw-Hill survey points out one new factor which, more than any other, is changing the nature of the investment process. This is the record outlay planned by U.S. corporations for **scientific research and development**—to create new products and develop new industrial processes. The rapid growth of research in industry, and plans for even more remarkable growth in the years ahead, are shown by the accompanying table.

This year industry plans to spend $7 billion on research and development — up 20% from 1956. By 1960 it will spend $9 billion—enough to create a major new industry.

By 1960 manufacturing industry expects sales to be up 26% —with half the increase in products that were not made in 1956.

Growth of Research and Development Expenditures

(Millions of Dollars)

			PLANNED	
	1955	1956	1957	1960
Machinery	408	506	577	704
Electrical Equipment	950	1,149	1,310	1,637
Aircraft and Parts	1,038	1,558	2,274	3,161
Fabricated Metal Products and Ordnance	134	165	174	210
Professional and Scientific Instruments	185	252	300	453
Chemicals	440	498	528	617
Paper, Rubber, Stone, Clay and Glass Products	149	174	196	233
Petroleum Products	171	205	225	277
Other Manufacturing	1,038	1,279	1,388	1,557
Non-manufacturing industries	254	310	347	419
ALL INDUSTRIES	4,767	6,096	7,319	9,269

What Research Is Doing

Here are some examples of how industrial research is opening up new markets, or compelling the modernization of old facilities:

New automatic controls in petroleum refining will raise the quality of gasoline and reduce the time required for production. A new process for recovering oil from depleted wells promises to multiply our potential reserves.

A new process for treating iron ore will permit the ore to be fed directly into steel furnaces—without the need for blast furnaces or coke ovens.

New turbine engines—made possible by the development of heat-resistant alloys for turbine parts—offer greatly increased power for aircraft, ships and automobiles.

Altogether, industry plans to introduce more new products in 1957-1960 than in any previous four-year period. It also plans new processes on a scale that will make much of our present capacity obsolete. These new products and new processes are the secret behind continuing plans for high investment.

One-third of all manufacturing firms are building new plants this year to produce new products, and by 1960 this may account for 10% to 20% of all capital expenditures. At the same time, manufacturing companies report that over half their capital expenditures in the next four years will be for modernization of equipment and introduction of new processes. Thus the preponderant share of new investment will be based on developments growing out of research.

A New Kind of Prosperity

The keen interest of U.S. business firms in scientific research points the way to a new kind of prosperity for our economy—a prosperity based on deliberate creativeness. As long as we can create new products that will offer better value to consumers or cut costs to manufacturing firms, business will continue at a high level—not at fever pitch, perhaps, and it is to be hoped not at an inflationary pitch. But based on a steady stream of new products and processes, we can have a high level of general prosperity that defies the old laws of boom and bust.

It's Not Automatic

Of course, there is no guarantee. New products do not spring up by magic as the medieval alchemists hoped they would. They are found as the result of long and expensive effort in laboratories and pilot plants. This effort requires an increasing number of trained scientists and engineers. In 1957 alone, manufacturing companies report they will need 7% more of these highly trained people in research and development. And by 1960, they will need an additional 15% to carry out planned research programs.

The effort to maintain prosperity — as well as the national defense effort — will depend increasingly on this supply of scientific and technical personnel. But if we can supply the people, industry now has the plans for a research effort that will put an end to the spectre of idle plants and idle workers.

This message is one of a series prepared by the McGraw-Hill Department of Economics to help increase public knowledge and understanding of important nation-wide developments. Permission is freely extended to newspapers, groups or individuals to quote or reprint all or parts of the text.

Donald C. McGraw

PRESIDENT

McGRAW-HILL PUBLISHING COMPANY, INC.

Elongation test of sample heelpiece metal typifies quality control measures that leave nothing to chance at Automatic Electric.

STANDARDS THAT DETERMINE RELAY QUALITY/

a distortion-proof heelpiece

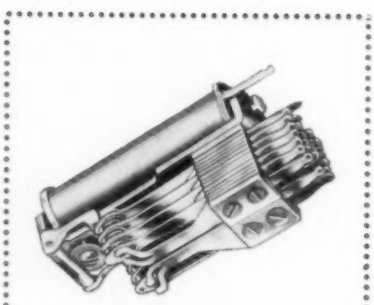
53 dimensional checks assure perfect alignment

The heelpiece of a relay is the platform on which all other parts rest. To maintain accurate contact spacing and pressure, the heelpiece must never shift, never twist, never bend.

We insure flatness and dimensional stability on both Class A and Class B relays, by planishing the heelpiece to relieve strains. In addition, we exercise unusual accuracy in the positioning, drilling and tapping of the holes, in forming the 90° angle bend, and in the contour of the armature end of the heelpiece.

On this single part, fifty-three specified dimensions are maintained and checked—many of which must be accurate to less than 0.002". Rigid tests and inspections safeguard the quality of the raw material itself—a very special sort of magnetic iron.

Care like this in the manufacture of each component makes it clear why Automatic Electric relays are the most reliable that money can buy.



Class "B" Relay, for outstanding endurance and dependability. *Write today for Bulletin 537.* Address: *Automatic Electric Sales Corporation, Northlake, Ill.* In Canada: *Automatic Electric Sales (Canada) Ltd., Toronto.* Offices in principal cities.

AUTOMATIC ELECTRIC

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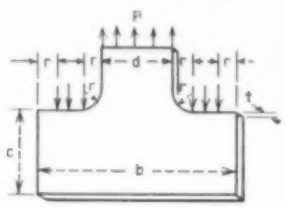
GENERAL TELEPHONE SYSTEM

Stress Concentration Factors—II

ALEXANDER GOMZA, *Group Leader, Grumman Aircraft Engineering Company*

This set of charts deals with bending stresses in T-heads and angles as well as plates. The previous set dealt with axially loaded plates and bars in which holes, notches, and shoulder fillets cause stress concentrations. One chart for an axially loaded plate and a corrected chart from part I of this article is also included here.

T-HEAD WITH DISTRIBUTED REACTIONS

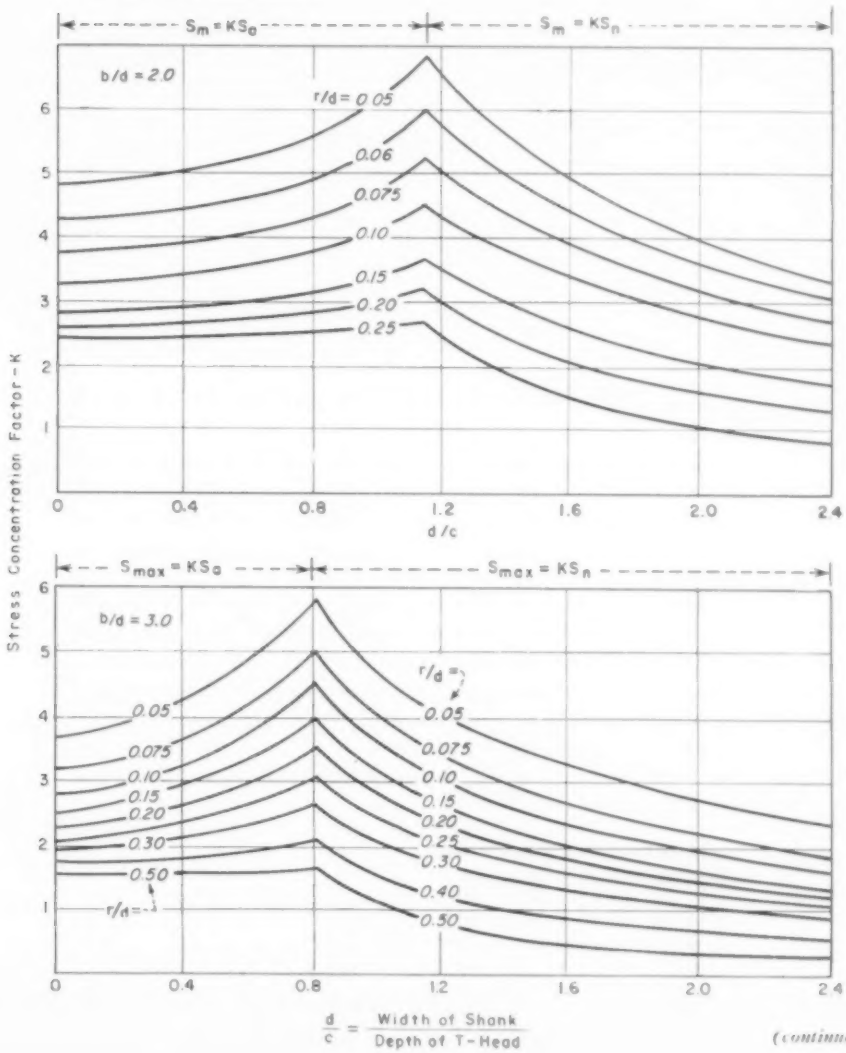


$S_a = \frac{P}{dt}$ = average stress in shank

$S_n = 0.75\, S_a \left(\frac{d}{c}\right)^2 \left(\frac{b}{d} - 1\right)$

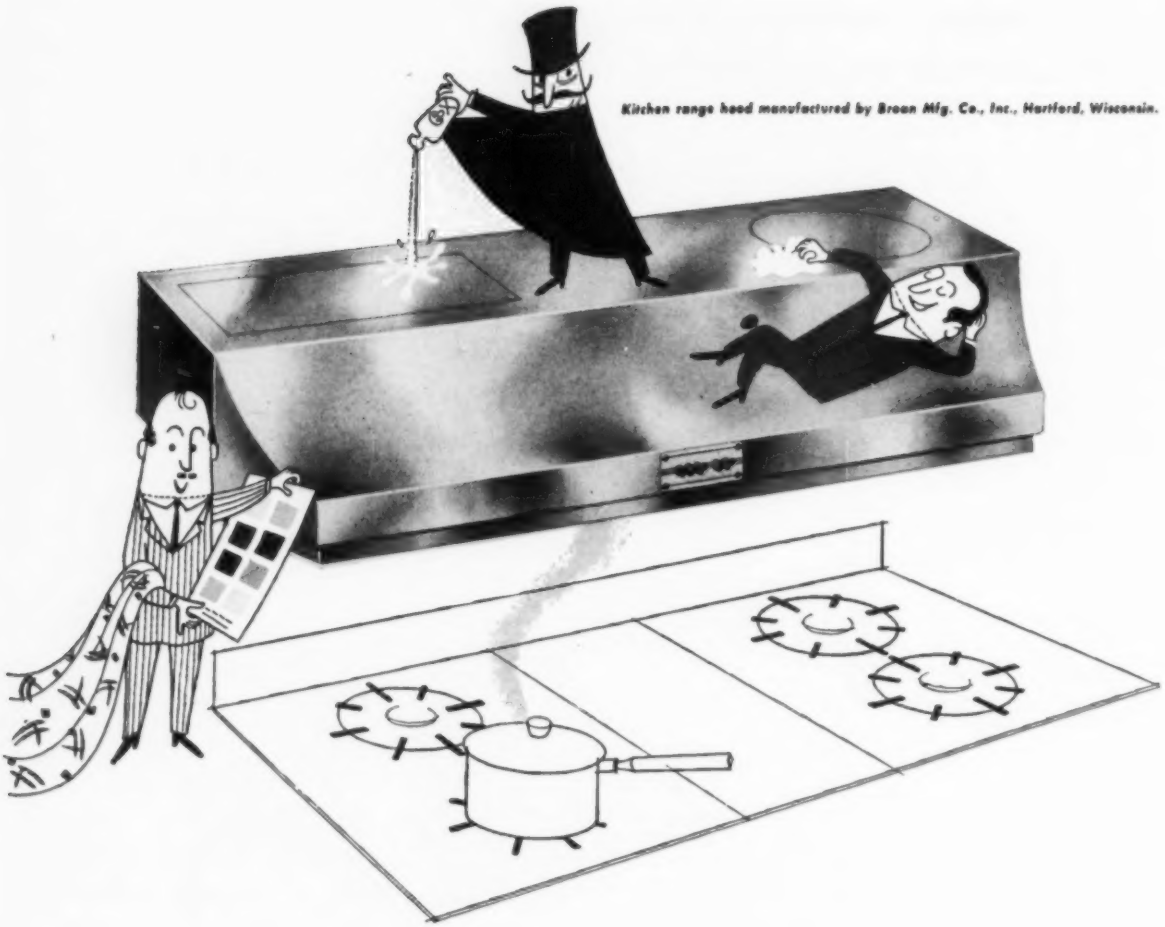
= nominal bending stress in T-head at fillet

S_m = maximum bending stress in head



$\frac{d}{c} = \frac{\text{Width of Shank}}{\text{Depth of T-Head}}$

(continued on page 217)



Kitchen range hood manufactured by Broan Mfg. Co., Inc., Hartford, Wisconsin.

Blends with all colors-resists acids–easy to clean

You get all 3 with products made of Crucible stainless

They're 3 selling advantages that put any product made of Crucible stainless steel way out ahead of the competition. This stainless steel exhaust hood, for example, cleans faster than any other kind. It has an eye-catching, smooth, shiny surface that withstands almost anything—even acids. And stainless steel's glitter-grey look blends with any color—anywhere. In fact, Crucible stainless enhances other colors by reflecting them. (Think how dealer inventories drop when 1 color satisfies all needs.) And think how far ahead your product would be with these selling advantages of Crucible stainless steel. To find out more about Crucible stainless, write for the handy Crucible Stainless Steel Selector. *Crucible Steel Company of America, The Oliver Building, Mellon Square, Pittsburgh 22, Pa.*

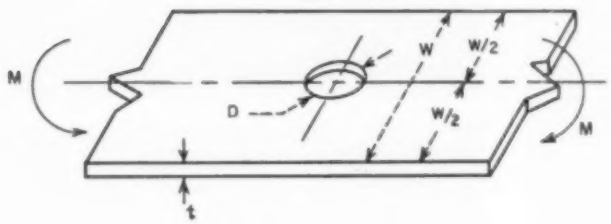
CRUCIBLE first name in special purpose steels

Crucible Steel Company of America

Canadian Distributor—Railway & Power Engineering Corp., Ltd.

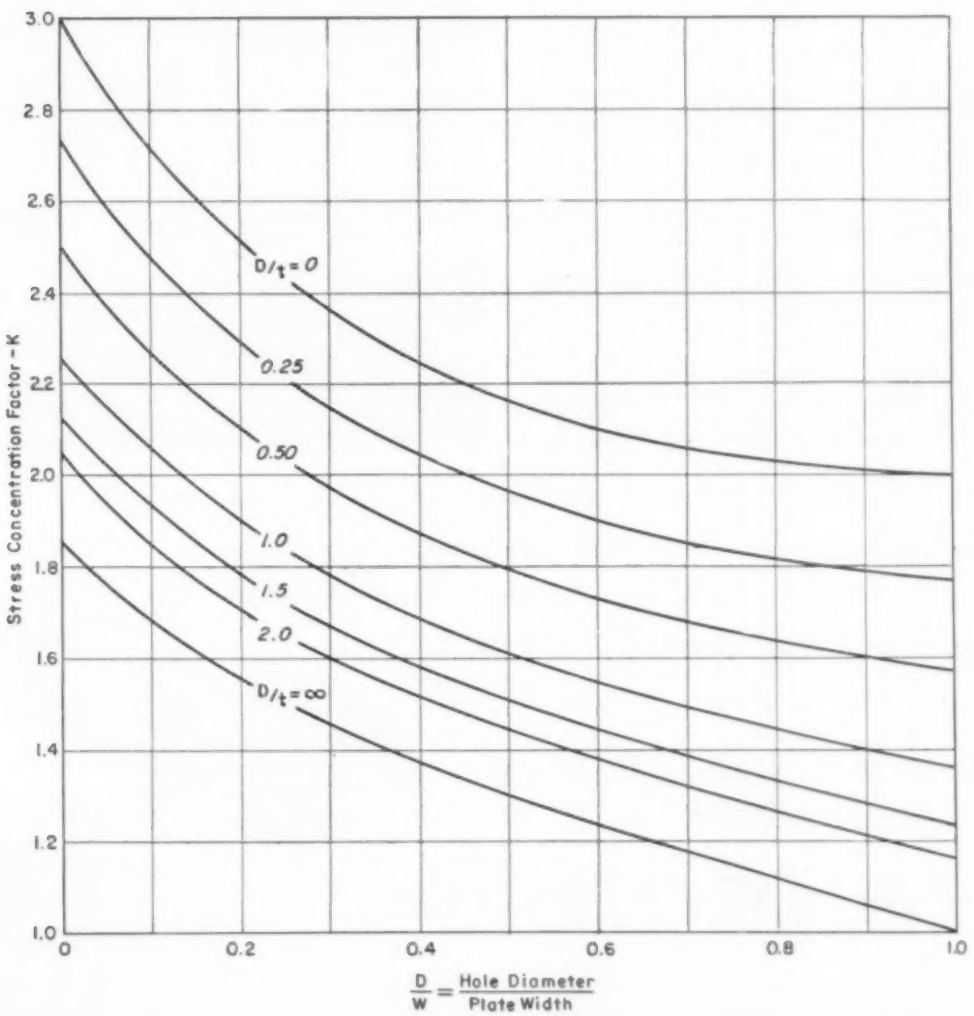
Stress Concentration Factors—II (continued)

PLATE IN BENDING WITH CENTRAL CIRCULAR HOLE



$S_m = KS_n$ = maximum stress at edge of hole

$S_n = \frac{6M}{(W-D)t^2}$ = nominal bending stress in outer fibers



(continued on page 219)

Tap and Fasten

In one operation

Immediate savings in time and money assured!

SHAKEPROOF
Thread-Cutting Screws

Special points, special heads, and special-purpose screws incorporating the Shakeproof Thread-Cutting slot provide added cost-cutting advantages.

• End separate tapping costs • Shakeproof Thread-Cutting Screws cut perfectly mated threads • Available in three styles for metals, die-castings and plastics • Can be removed and re-used • Extra strength due to heat treating • Available in all standard head styles, pre-assembled as Sems, and in many special application designs as shown above.

Write for sample kit containing Shakeproof Thread-Cutting Screw assortment

SHAKEPROOF

"FASTENING HEADQUARTERS"

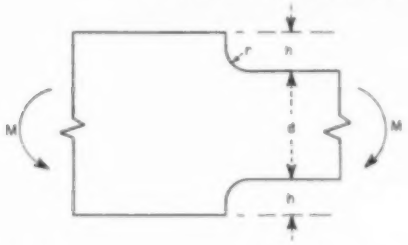
DIVISION OF ILLINOIS TOOL WORKS

St. Charles Road, Elgin, Illinois • Offices In Principal Cities
In Canada: SHAKEPROOF-FASTEX, Division of Canada Illinois Tools, Ltd., Toronto, Ontario

itw

Stress Concentration Factors—II (continued)

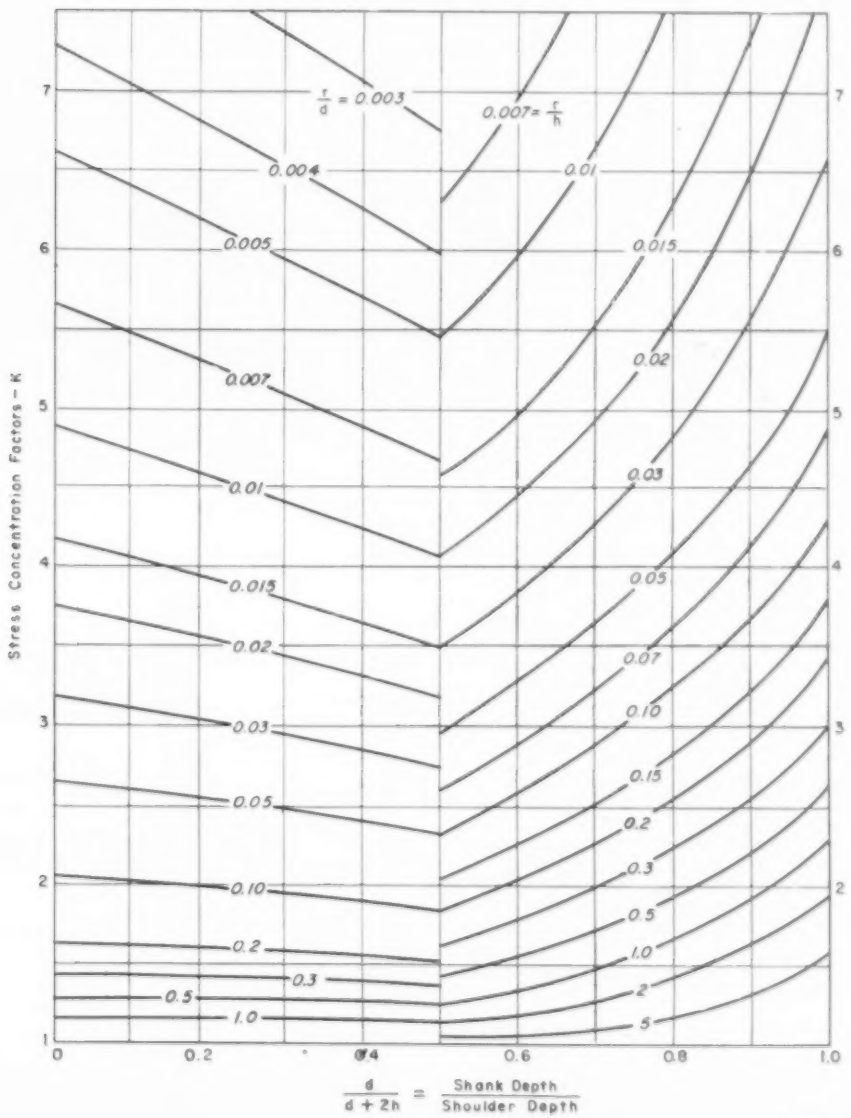
PLATE WITH A SHOULDER FILLET - BENDING



$S_m = KS_n$ = maximum outer fiber bending stress in shank

$S_n = \frac{6M}{d^2 t}$ = nominal outer fiber bending stress in shank

t = plate thickness



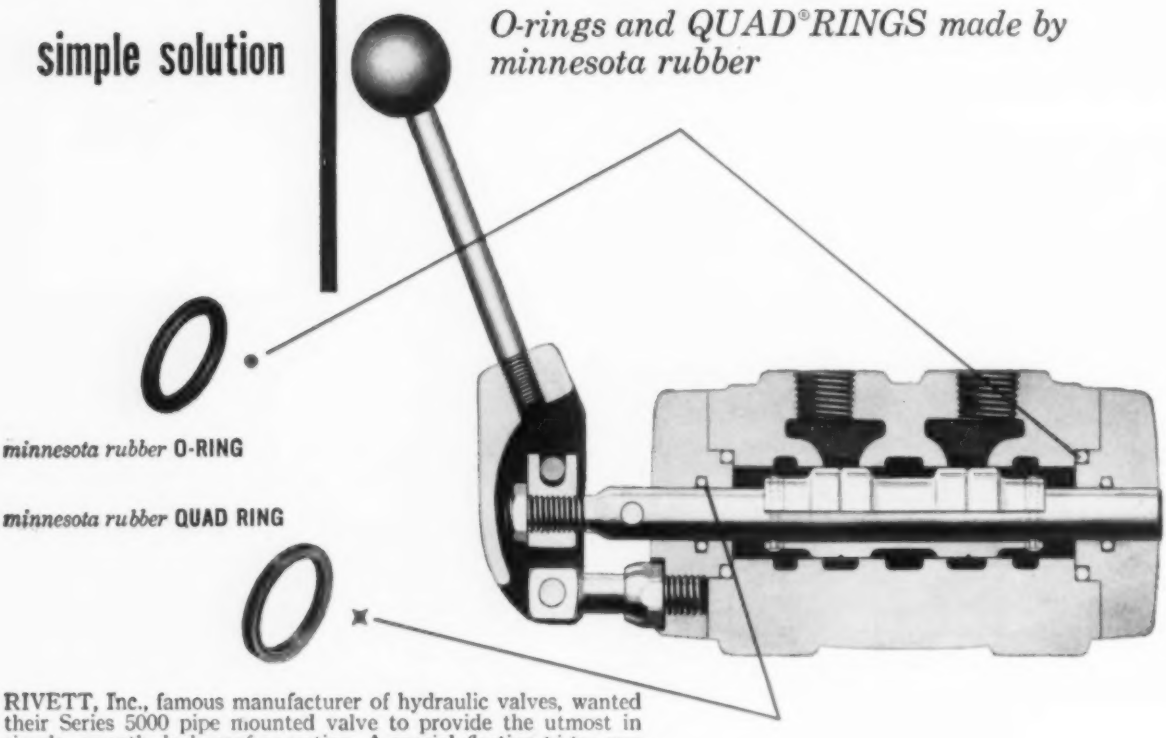
(continued on page 221)

hydraulics problem

how to eliminate gaskets and reduce friction to improve design of a pipe mounted valve

simple solution

O-rings and QUAD®RINGS made by minnesota rubber



minnesota rubber **O-RING**

minnesota rubber **QUAD RING**

RIVETT, Inc., famous manufacturer of hydraulic valves, wanted their Series 5000 pipe mounted valve to provide the utmost in simple, smooth, leakproof operation. A special *floating piston* was incorporated in the design of the valve. This exclusive feature eliminated sticking or binding by keeping the valve stem independent of the bore. To provide a stem seal that would greatly reduce friction, RIVETT chose the Minnesota Rubber QUAD RING. This exclusive seal provided a perfect seal with much less squeeze making operation easier. To obtain design simplicity, more efficient operation and longer life, gaskets were eliminated and replaced by Minnesota Rubber O-Ring cover seals. This combination of advanced design elements and Minnesota Rubber Seals permits multi-million cycle operation at 1500 PSI.

What Minnesota Rubber Seals offer you. An exclusive injection molding process means that Minnesota Rubber QUAD RINGS, O-Rings and other rubber parts are denser and tougher. Their tremendous uniformity and strength mean greater dependability, longer life. Quad Rings give you 4-lip sealing action, seal at less than 1 PSI, require only 60-100 micro-inch groove finish and eliminate "spiral twist." Minnesota Rubber O-Rings are available to you with tolerances as close as ± .002", cost as little as ordinary O-Rings and are produced with no flash or other imperfections that require trimming. An enormous selection of standard sizes assure immediate delivery.

Note: QUAD RING is a Trade Mark of the Minnesota Rubber & Gasket Co.

Free samples and data. A sample of Minnesota Rubber seals is available together with complete technical data. Simply write . . .

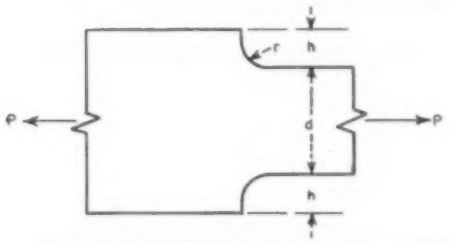
minnesota rubber and gasket company

Originators of modern rubber injection molding.

Dept. 204, 3630 Wooddale Ave., Minneapolis 16, Minnesota; Phone: WEst 9-6781

Stress Concentration Factors—II (continued)

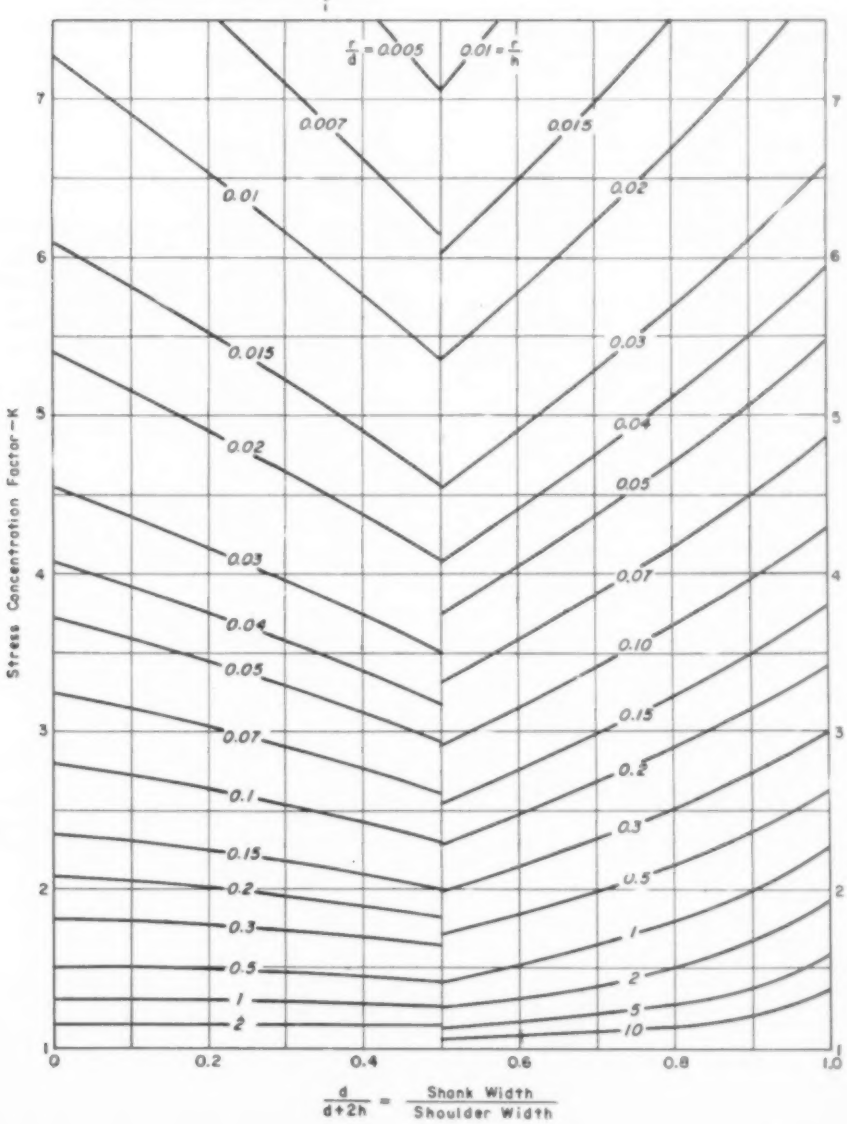
FLAT PLATE WITH SHOULDER FILLET UNDER AXIAL LOAD



$S_0 = \frac{P}{dt}$ = average stress in shank

t = plate thickness

$S_m = KS_0$ = maximum stress in shank



(continued on page 223)

NEW GOLDEN BONDERITE

How its golden color can mean better products, greater profits for aluminum fabricators

The golden coating achieved on aluminum by new Golden Bonderite is the key to a whole new concept in control, economy and efficiency.

No longer need you worry along with variations in coating weights and solution analyses that go up and down from hour to hour or day to day. The color of the metal as it emerges from the Bonderite machine is a visual check on solution effectiveness and coating quality. It looks the same—and it is the same—24 hours a day, seven days a week.

Parker "Reactifier" and How It Works

In ordinary surface treatment solutions of this kind, a build-up of impurities occurs as work is processed. These impurities affect the efficiency of the treatment in inverse ratio until finally the solution is beyond redeeming. The tank has to be dumped and a fresh bath made up.

This costly, wasteful procedure is ended when you use Golden Bonderite in conjunction with the sensational Parker "Reactifier" column, an exclusive apparatus that polices the solution constantly, removing the harmful elements and allowing you to use the solution indefinitely, without ever having to discard it.

Better Products, Better Profit

You use a surface treatment for your aluminum production to improve paint adhesion and corrosion resistance, to reduce rejects in the finishing department and to assure customer satisfaction. Uneven efficiency in surface treatment usually means loss of paint adhesion, production rejects and the danger of costly field service and replacements.

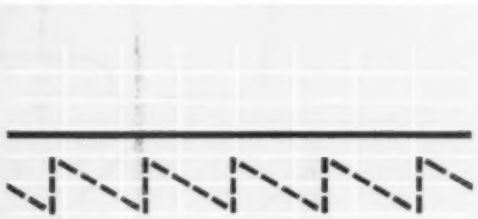
Golden Bonderite's uniform efficiency, so easily checked by color, will save you money.

1 It provides a uniform, effective paint base.

2 It allows you to schedule and maintain high production levels.

3 It permits operation at uniform low chemical concentrations.

4 It eliminates the need for dumping and rebuilding treatment solution.



Straight-as-a-string solution analysis

The saw-tooth line above is entirely too familiar to operators of conventional aluminum treatments. Efficiency sags as metal is treated, recovers as chemical is added, quickly sags again in use. Quality is uneven and uncertain.

New Golden Bonderite and the amazing new "Reactifier", developed by Parker, bring "straight-as-a-string" efficiency. No variation in quality even if you operate 24 hours a day, seven days a week. Solution analysis remains constant, free of impurities that reduce efficiency and quality.

Simple To Use

New Golden Bonderite may be applied by spray or immersion. Treatment time can be varied to suit production speeds and equipment. Golden Bonderite comes to you in concentrated liquid form, easy to handle and use.

Let us show you actual samples and test data on Golden Bonderite for aluminum. Call or write today!

NOTE: *A companion product to Golden Bonderite produces an appealing scratch-resistant green coating on aluminum. It's a lovely color without further finishing. A natural for architectural products.*

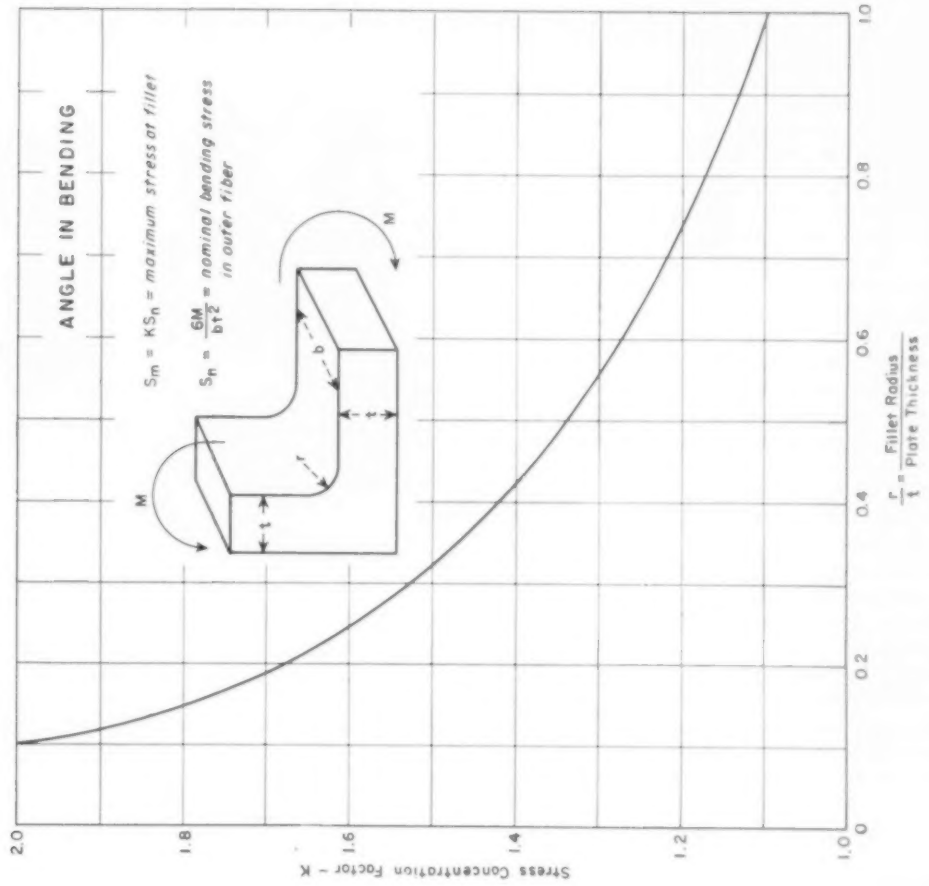
Since 1914—leader in the field

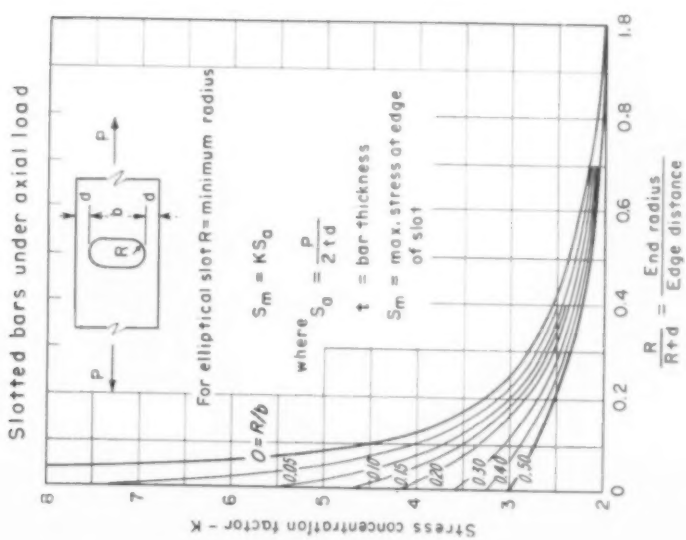
PARKER RUST PROOF COMPANY
2179 E. MILWAUKEE, DETROIT 11, MICHIGAN

BONDERITE	BONDERITE and BONDERLUBE	PARCO COMPOUND	PARCO LUBRITE	TROPICAL
corrosion resistant paint base	aids in cold forming of metals	rust resistant	wear resistant for friction surfaces	heavy duty maintenance paints since 1883

**Bonderite, Bonderlube, Parco, Parco Lubrite, Parker Pre-Namel—Reg. U.S. Pat. Off.*

Stress Concentration Factors—II (continued)





This is a corrected reproduction of the chart which appeared on page 211 of last month's issue.

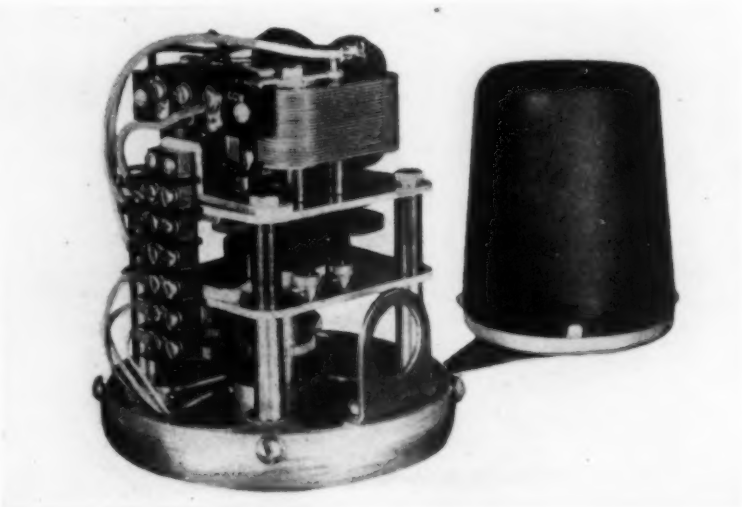
NEW COMPONENTS

Gear Motor Provides Remote Control

A shaft-mounted gear motor provides remote electrical control of position or speed, with indication on a calibrated meter, by means of a built-in potentiometer. Components, such as valves, variable speed drives, gates, jacks and variable displacement pumps, may be controlled. The potentiometer may also serve in bridge circuits of automatic control systems. Control may be by dial control, by pushbutton, or it may be automatic, by means of limit switches, controllers, or proportioning devices.

The device mounts on shafts from ¼ to 1 in. dia. A torque arm compensates for any runout that may be present in the shaft on which the control is mounted.

A wide range of operating speeds and torques may be handled by specifying the desired ratio of the three or four-stage reduction gearing. A variety of potentiometer ratios may also be obtained, so that full-scale deflection of the calibrated meter may be obtained for rotation of the shaft from ⅛ to 40 or more revolutions.



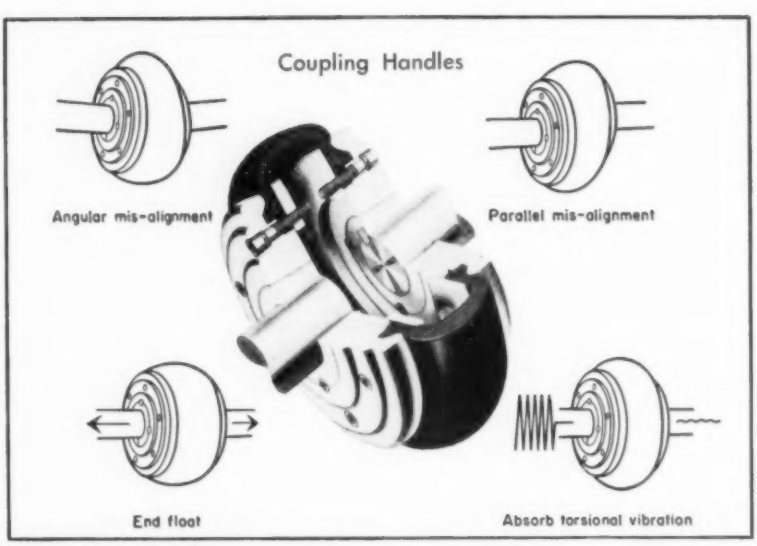
Single or multi-turn potentiometers can be obtained. When the potentiometer is used as a part of a bridge circuit, the standard control provides follow-up accuracies of ±0.20% of full scale. With precision multi-turn potentiometers, accuracies of ±0.04% can be provided. The controls, for use on single or three-phase circuits, are drip-proof, totally enclosed, explosion-proof. Jordan Co., 3235 W. Hampton Ave., Milwaukee 9, Wis.

For more information—
Circle 1, inside back cover

Flexible Cushion Coupling

The ability to handle angular misalignment, parallel misalignment and end float, are advantages claimed for this coupling. The flexible member also cushions shock loads and diminishes torsional vibration.

The unit consists of the flexible tire clamped between two hubs which are mounted on the shafts to be coupled. The flexible member is held between the flanges and clamp rings of the hubs. The tire has a transverse split molded into it, which permits easy installation and makes replacement pos-



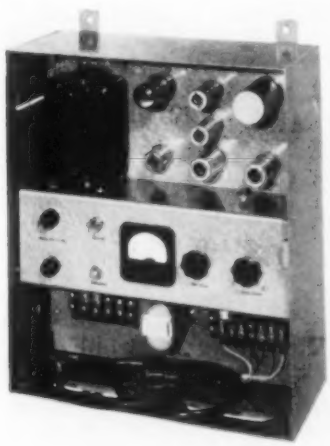
sible without moving driver or driven machine.

The unit is said to take angular misalignment up to 4°, parallel misalignment up to $\frac{1}{8}$ in., and end float up to $\frac{5}{16}$ in. Because there is no metal-to-metal contact, lubrication is not required. Available in capacities up to 600 hp at 900 rpm. Dodge Mfg. Co., Mishawaka, Ind.

For more information—
Circle 2, inside back cover

Electronic Sensing Control

An electronic capacitance control has been designed to detect the correct position or size of all metallic objects without direct contact. The control is set up to a given constant, at a set time interval, and then recognizes deviations from the constant. It not only recognizes an error, but also indicates how the sensed object is wrong. The unit has no moving parts and is surrounded by protective insulator material.

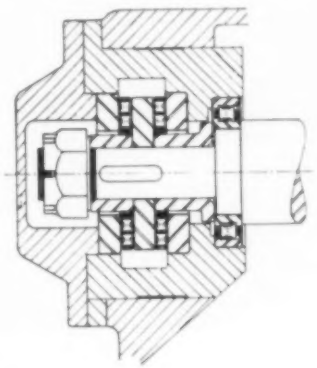


One unit may use up to three sensing elements. The element will detect objects up to 2 in. away and at close proximity can recognize deviations of $\frac{1}{8}$ in. Operates on 115 v, 60 cps power. Security Controls, Inc., 257 Franklin St., Buffalo 2, N. Y.

For more information—
Circle 3, inside back cover

Double-Acting Thrust Bearing

This double-acting thrust bearing is designed to withstand extremely heavy thrust loads from either direction. Flat-seat type bearing, with 2 in. bore and 6$\frac{7}{8}$ in. OD, consists of center plate, roller assemblies, stationary plates, and rotating inner sleeves.



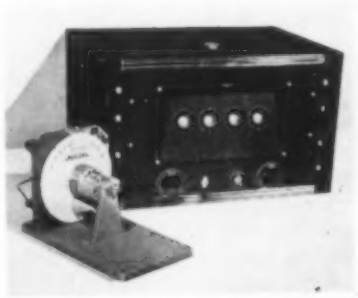
Plates, $\frac{7}{8}$-in. thick, are held to extremely close parallelism to maintain maximum linear contact. Inner sleeves and center plate are keyed to pinion shaft to insure positive rotation under all conditions. Stationary plates are ground on OD for slip fit in the housing, with bores providing proper clearance around inner sleeves.

Machined bronze retainers contain four $\frac{1}{2}$ in. dia rollers in each of 16 slots. Thrust capacity is 17,550 lb at 750 rpm. Rollway Bearing Co., 541 Seymour St., Syracuse, N. Y.

For more information—
Circle 4, inside back cover

Dynamometers Test Induction Motors

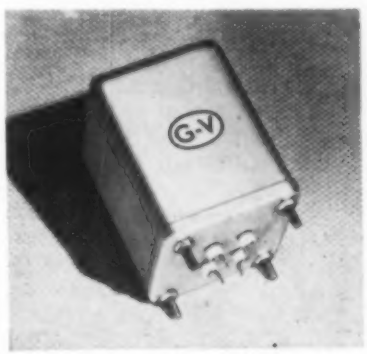
These dynamometers, used to run performance curves on all types of induction motors, particularly shaded pole motors, up to approximately 5 hp, test torque and speed. Six basic models have torque ranges of 0-16, 0-32, 0-100, 0-200, 0-350, and 0-750 in.-oz. The accuracy is 1% of the maximum torque reading. The tachometer generator can be supplied to



indicate speed up to 8000 by 1 rpm increments, or a maximum of 30,000 rpm by 10 rpms increments. Available in either a bench cabinet or a 19 in. rack mounting unit.

Testing the curve below breakdown torque with conventional dynamometers is usually difficult because the unit's torque does not decrease with the motor torque. In this unit, dynamometer torque is determined by the motor torque because of feedback control. Consequently, when a decrease in speed is detected, a corresponding decrease in the load torque is instantaneously effected and the motor speed stabilized in any portion of the curve. Magtrol, Inc., P. O. Box 193, Bridge Sta., Niagara Falls, N. Y.

For more information—
Circle 5, inside back cover



Instant Reset Thermal Delay

A thermal time delay resets instantly when its energizing circuit is interrupted, either during the timing cycle or after its completion. Time delay unit contains thermal and mag-

CONTINUED ON PAGE 226

netic elements mounted in a single case for standard delay intervals of 2, 5, 15, 20, 30, 60, 120, 180, and 300 sec. Energizing voltage is 28 v d-c. Time delay tolerance is ±10%.

Output contacts are either normally open or normally closed, single-pole, single-throw. Contacts are rated at 2 amp up to 230 v a-c and 1 amp up to 32 v d-c. Energizing power averages 6 w during the timing cycle.

The unit is in a hermetically sealed case 2 5/16 x 2 5/8 x 3 3/16 in. Ambient temperature range is −65 C to 125 C and will withstand shock of 30 g and 10 g vibration over the 5 to 500 cps range. G-V Controls Inc., Hollywood Pl., E. Orange, N. J.

For more information—
Circle 6, inside back cover

Self-Threading Locknut

The cost of threading such elements as die-cast studs or rolling threads on wire or cold-forged parts is said to be eliminated with this self-threading locknut that cuts its own threads while tightening. The fastener is made of spring-tempered steel, comprising a thread-cutting locknut and flat washer in one piece, for 1/4, 5/16 and 3/8 in. unthreaded studs.

The nut is hex form. It may be removed and reused on the same studs. Resilient washer base assures full 360° contact on flat or irregular work surfaces, and on perpendicular or off-angle studs. Palnut Co., Glen Road, Mountainside, N. J.

For more information—
Circle 7, inside back cover

High-Temperature Glass

A non-porous material that is lighter than aluminum and up to nine times stronger than plate glass. Called Pyroceram, it can have electrical insulating properties superior to commercial dielectric ceramics. The material can be formed by investment casting techniques and has a flexural strength of 40,000 psi. Thermal shock resistance of the crystalline material is said to be greater than that of dense alumina and equal to that of fused silica. Among its present applications are radomes for guided missiles. Corning Glass Works, Corning, N. Y.

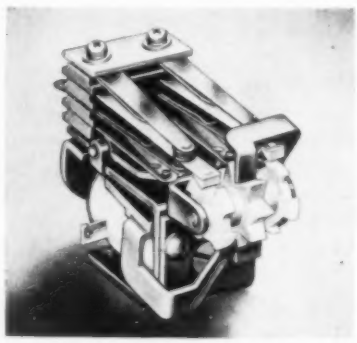
For more information—
Circle 8, inside back cover

	Pyroceram 8605	Stainless Steel Type 302 Annealed
Specific Gravity 25C	2.62	7.93
Thermal Conductivity (cgs) 25C	0.0100	0.052
Linear Coef. of Thermal Expansion X 10^7 (25 to 300C)	14	95 (−18 to 316C)
Modulus of Elasticity (psi x 10^{-6})	19.8	29
Hardness: Knoop (500 gm)	720	147-201
Strength-to-weight Ratio	14.1	10.1

Sequence Relays

Midget sequence relays with double-pole, single-throw and double-pole, double-throw arrangements can be used wherever a predetermined cycle of operation is needed. A double cam movement permits contacts to be adjusted to operate when the coil is de-energized. The cam rotates a half step when the coil is energized, and completes the step when de-energized.

Relays are equipped with double-pole or double-pole, double-throw



contacts which may be set to open, close, or transfer in any desired sequence, providing the number of steps in a complete cycle is divisible into six or eight, (the number of teeth on available ratchets).

Coils in ratings up to 115 v d-c, or 230 v a-c are available. Power consumption is 5 to 6 w d-c, or 10 to 12 va a-c. Heavy flexing contacts will carry 150% of rated load. Contacts are fine silver convex buttons, mounted on phosphor-bronze flexing arms. Ratings are 5 amp a-c; or 0.5 amp d-c at 115 v; and 5 amp d-c at 24 v. Struthers-Dunn, Inc., Pitman, N. J.

For more information—
Circle 9, inside back cover

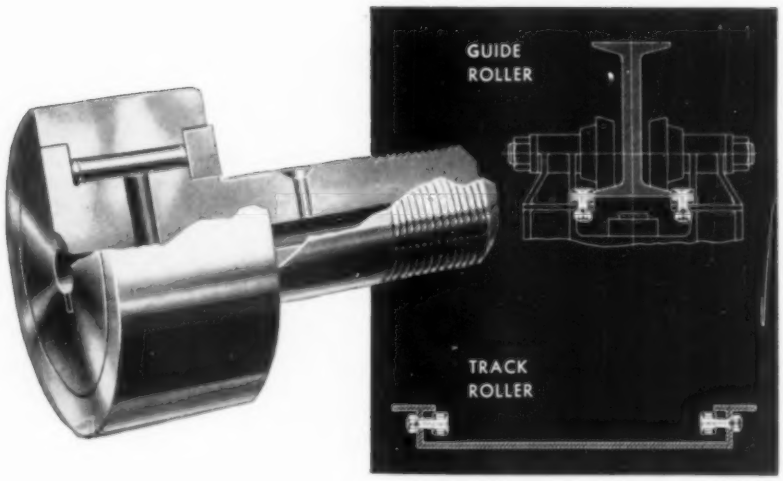
Cylindrical Rule

This new calculator, by spiraling the scales around a tube instead of in a straight line, achieves graduations equal to those of a 66-in. slide rule. The cylindrical calculator may be used to solve all problems involving multiplication, division, proportion, percentages, logarithms, roots, and powers. The plastic-covered scales are

CONTINUED ON PAGE 228

BEARING TIPS by McGill

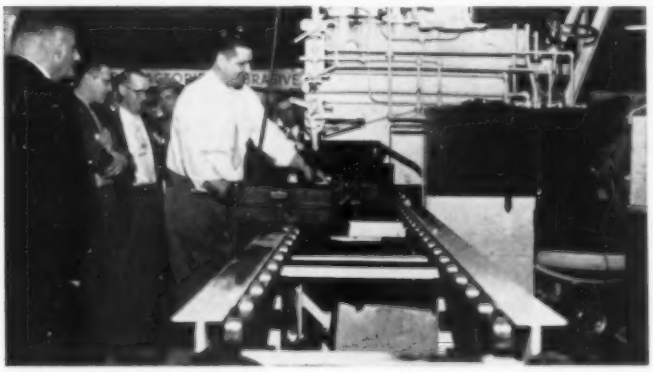
Let a CAMROL bearing be your guide



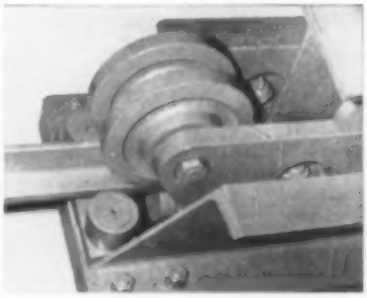
Obtain freer rolling, improved alignment and positive side thrust

In guide and support roller applications CAMROL Cam Followers insure free rolling action and positive side thrust while eliminating the wear of more costly flanged wheels. Then, too, they provide improved alignment and low starting and running friction with high unit load and shock capacity, especially at low speeds as track rollers. Lubrication is simplified and maintenance can be reduced to a minimum in these applications. Specify the interchangeable sealed SGR series for added protection against contamination.

CAMROL CF bearings provide friction-free track rollers for automatic mold blower



McGill CAMROL CF rollers are used as guide rollers to form a mold conveyor in the Beardsley & Piper MBS-20 Mold Blower. The machine blows and squeezes cope or drag in a single automatic operation, handling up to 4 molds per minute. The CAMROL CF bearings replaced less efficient friction rollers in this application. Although, the duty here is rather light and speeds slow, the cam follower bearing provides lesser starting and running friction. This helps speed the flow of work from the machine, which must be fast and automatic. The integral stud feature eases assembly and its standard design simplifies procurement.



CF bearings minimize maintenance as crane side guide rollers

McGill CF cam follower bearings serve as side guide rollers in overhead cranes manufactured by Louden Machinery Company of Fairfield, Iowa. Freedom from maintenance, a time saver because of the inaccessibility of the bearing when the crane is in operation, is an important advantage of the cam follower bearing.

Send for Catalog No. 52-A

Insure performance with McGILL®

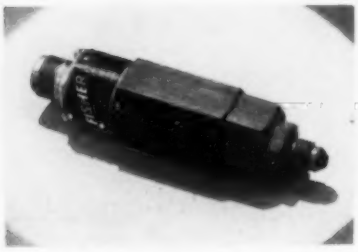
MULTIROL® · GUIDEROL® CAMROL
Precision Needle Bearings

McGILL MANUFACTURING COMPANY, INC., 201 N. LAFAYETTE ST., VALPARAISO, INDIANA

resistant to wear and moisture, and since all parts of the instrument are made of metal throughout, there is no possibility of warping or distortion.

Though the instrument can be opened to 10¼ x 1¼ in., its size when closed is only 6 x 1¼ in. Arthur F. Smith Co., 311 Allexander St., Rochester, N. Y.

For more information—
Circle 10, inside back cover



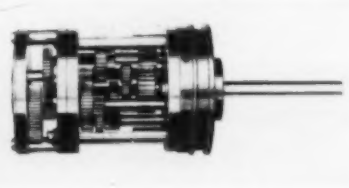
In-Line Pressure Switch

Designed for hydraulic, fuel and pneumatic systems, this piston-type pressure sensing unit will perform under fast continuous operation unaffected by jarring or vibration. A compression spring controls the point of actuation and is externally adjusted.

Standard units with ⅜ in. male tube size or ¼ in. male pipe pressure connection and an AND type electrical connection are available from 100 to 3500 psi. These valves, weighing 3 oz, are 3 in. long and have an operating temperature of −65 F to 165 F and an electrical rating of 15 amp at 120 v a-c. Fisher Controls Inc., 1222-7 St., Santa Monica, Calif.

For more information—
Circle 11, inside back cover

MECHANICAL COMPONENTS



Motor Gear Head

For use with Size 11 motors, this tandem design provides ratios to 3 million: 1 and higher, while maintaining the low backlash of much smaller ratio units. The operating load torque is 25 oz-in., starting torque 0.005 oz-in. Bearing plates are passivated stainless steel, as are the gear clusters. Bowmar Instrument Corp., 2402 Pennsylvania St., Fort Wayne, Ind.

For more information—
Circle 12, inside back cover

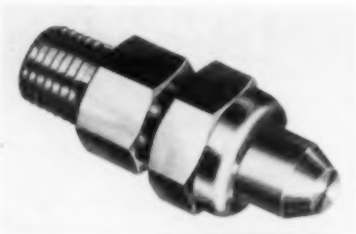
Miniature Bellows

A bellows with wall sections 0.002 in. is available in any weldable metal. The unit is approximately ¾ in. OD x ¼ in. ID x ½ in. long and has a spring rate less than 7 in.-lb. The BeLfab Corp., 11 Ramah Circle, Agawam, Mass.

For more information—
Circle 13, inside back cover

Spray Nozzles

Twelve different nozzles are offered in both male and female pipe connections—capacities ranging from 0.042 gpm to 1.4 gpm at 20 psi. The full cone spray pattern of the nozzle

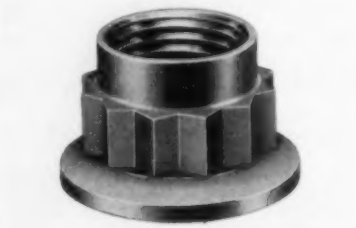


is uniform in distribution and the spray angle ranges from 50 to 67° as capacity increases. Spraying Systems Co., Randolph St., Bellwood, Ill.

For more information—
Circle 14, inside back cover

Self-Locking Nut

A 12-point nut designed to develop full strength of 180,000 psi high-tensile bolts is a one-piece all-metal unit suitable for use in temperatures up to



550 F. The nut combines a self-locking, high-strength element with a permanent-type molybdenum disulfide lubricant. This combination provides consistent torques over a wide temperature range which results directly in uniform preload in the bolted joint and thereby assures maximum fatigue resistance. Nuts are available in sizes ¼-28 through ½-20. Kaynar Co., Box 2001 Terminal Annex, Los Angeles 54, Calif.

For more information—
Circle 15, inside back cover

Quick-Release Pins

These pins may be used as shear-pins, lock-pins, hinge-pins and clevis-pins. The locking buttons are activated by silicone rubber cores, providing for a vibrationproof locking method which is also corrosion and temperature resistant. Pins have solid shanks and are made of stainless or high tensile

CONTINUED ON PAGE 230

CMP

RESTRICTED SPECIFICATION
COLD ROLLED STRIP STEEL

Serves Typical Low Carbon End Use Requirements Such as these . . .

SIZE	8 x .045
ANALYSIS	1010
FINISH	#2 finish
HARDNESS	Non-Scalloping quality
THICKNESS TOLERANCE	± .0005 Incl. crown
WIDTH TOLERANCE	± .005
COIL SIZE	250# per inch of width
PACKAGING	Skidded

SIZE	12 x .032
ANALYSIS	1010
FINISH	#3 finish
HARDNESS	#4 Temper
THICKNESS TOLERANCE	± .0005 Incl. crown
WIDTH TOLERANCE	± .005
COIL SIZE	up to 200# per inch of width
PACKAGING	Paper interleaved—skidded and shrouded

SIZE	4 x .085
ANALYSIS	1010
FINISH	#2 finish
HARDNESS	#3 Temper
THICKNESS TOLERANCE	± .0005 Incl. crown
WIDTH TOLERANCE	± .005
COIL SIZE	Cut lengths
PACKAGING	Skidded

Many times, by varying processing methods, CMP is able to develop properties in cold rolled strip steel which greatly facilitate production operations and/or give the product superior qualities without adding to end product cost. End result is lower costs through improved products or better assembly and improved yield.

We believe you will find it worthwhile to investigate the possibilities of CMP Restricted Specification Cold Rolled Strip Steel applied to your production.

THE 3 IN 1 SOURCE

FOR YOUR COLD ROLLED STRIP STEEL

Now there are three CMP plants with facilities for production of "Restricted Specification" cold roiled strip. Strategic locations at Youngstown, Indianapolis and Los Angeles, provide the security of 3 sources of supply plus the close working relationship which these local production centers make possible.

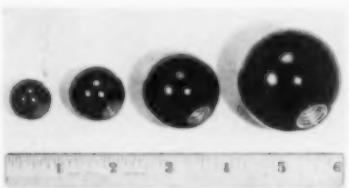
CMP PRODUCTS

Low Carbon, High Carbon — Annealed or Tempered, Stainless, Alloy, Electro Zinc Coated.

THE COLD METAL PRODUCTS CO.
GENERAL OFFICES: YOUNGSTOWN 1, OHIO
PLANTS: YOUNGSTOWN, INDIANAPOLIS AND LOS ANGELES
SALES OFFICES: NEW YORK - CLEVELAND - DETROIT - INDIANAPOLIS
CHICAGO - LOS ANGELES - SAN FRANCISCO

chrome-molybdenum steels for maximum shear strength. They are available in grip-lengths and diameters from ¼ in. Waldick Engineering Co., Box 221, Garden City, N. Y.

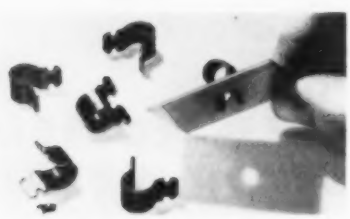
For more information—
Circle 16, inside back cover



Plastic Knobs

Designed to be used on control levers, these knobs are available with ⅛, ¼-20 brass inserts and are made in standard phenolic or bakelite colors ranging from ¾ in. to 1⅝ in. dia. Knobs can be molded for specific applications requiring special characteristics, such as, heat resistance up to 500 F. Dimco-Gray Co., 207 E. 6 St., Dayton, Ohio.

For more information—
Circle 17, inside back cover



Nylon Cable Clips

The advantages of nylon are incorporated in these one-piece clips. The installer simply pinches the ends of the clip together, inserts it in a mounting hole and lets go. Weckesser Co., Dept. PEN, 5701 Northwest Highway, Chicago 30, Ill.

For more information—
Circle 18, inside back cover

Caster With Dual Brake

This caster, built for heavy loads, may be used for engine stands, scaffolds and general industrial applications. Brake simultaneously locks both swivel and wheel, assuring absolute safety—prevents "walking." Brake action compensates for wheel wear. Faultless Caster Corp., Evansville, Ind.

For more information—
Circle 19, inside back cover

Vibration Isolation Mounting

Mounting has load capacities above 60 lb, and temperature resistance from −80 F to 250 F. They support loads in either the upward or downward direction. Lord Mfg. Co., 1635 W. 12 St., Erie, Pa.

For more information—
Circle 20, inside back cover

Machine Bases

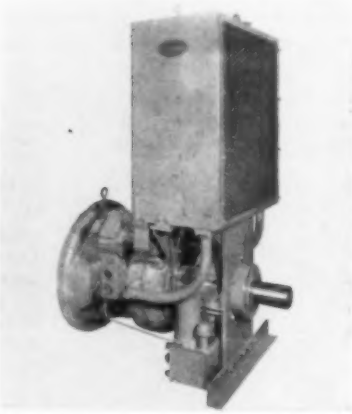
These bases, which come knockdown, are made of steel plate ranging from $\frac{5}{8}$ to $\frac{5}{16}$ in. in thickness. The parts are so designed that any size of base from 24 to 48 in. in length or width and from 24 to 54 in. in height may be quickly assembled, the parts being drilled so that they can be bolted together for welding. Inter-Lakes Engineering Co., 39200 Groesbeck Hwy., Mount Clemens, Mich.

For more information—
Circle 21, inside back cover

Knob With Fluted Collet Fitting

A military style fluted knob, with collet fitting attachment assures locking on shafts under vibration and shock conditions. The collet is actuated by a slotted cap screw made to fit screwdrivers, it grips the shaft, evenly distributing locking pressure on all outside surfaces. It has a 1 in. dia. and is ¾ in. high. The knob material is thermoplastic. Dale Products, Inc., Columbus, Neb.

For more information—
Circle 22, inside back cover



Three-Stage Torque Converter

The unit has a maximum rating of 586 hp at 2200 rpm. Impellers are available for specific torque ratings of 340, 390, 450 and 540 lb-ft. Maxi-

CONTINUED ON PAGE 232

This container holds the solution

to most sleeve bearing problems

The container holds PERMAWICK . . . the *revolutionary* "self-wicking" lubricant.

Permawick Solves Materials Problems. Because PERMAWICK is wicking material and oil combined in a single fluid form . . . it replaces all felts, related parts and separate purchasing and testing of individual components.

Permawick Solves Production Problems. Because PERMAWICK is injected automatically by high speed production machines . . . it eliminates all costly hand insertion operations.

Permawick Solves Design Problems. Because PERMAWICK is a fluid, injected under pressure . . . it flows over ribs, around sharp corners and through small channels, to completely fill any shaped cavity. Bearings can now be designed with proper rib construction for maximum strength.

Permawick Solves Oil Capacity Problems. Because PERMAWICK is 85.7% oil by weight . . . it provides twice the oil of felt systems, in the same size cavity.

Today, leading manufacturers of motors, blowers, pumps and similar products are using PERMAWICK as an important *profit saving* part of their production process. Whether you use solid or sintered type sleeve bearings, PERMAWICK can solve your specific problems. *Write for complete information.*

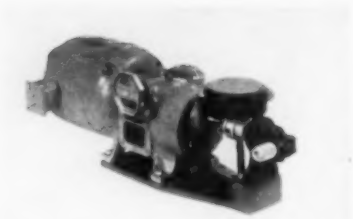
*A PATENTED PRODUCT BY . . .

Fluidwick COMPANY

5319 EAST OUTER DRIVE
DETROIT 34, MICHIGAN

mum input torque is 1400 lb-ft. Units include model which provides a clutch at the flywheel, and another connected to the flywheel with a driving ring. Both types are designed for SAE No. 0 flywheel housings. Twin Disc Clutch Co., Rockford, Ill.

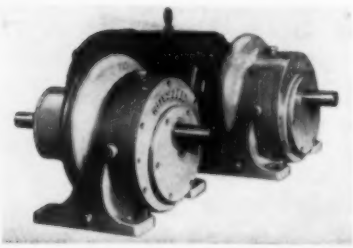
For more information—
Circle 23, inside back cover



Circulating Lubrication System

This system includes a variable discharge pump and motor unit. Adjustable volume control is available in two ranges, from 5 to 30 and 16 to 100 cu in., min. Positive discharge at any setting is assured regardless of required system pressure. A pressure switch is part of the pumping unit which may be set for wide normal operating range. Inability of any bearing or line to receive oil due to high or low pressure, low oil supply, blocked oil line will actuate the alarm signal blinker lights. Trabon Engineering Corp., 28701 Aurora Road, Solon, Ohio.

For more information—
Circle 24, inside back cover



Parallel Shaft Reducer

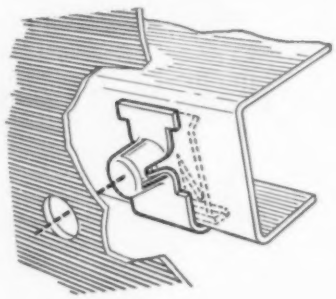
These units are without motors; the design permits the input shaft to be driven by either a coupling, chain, or V-belt drive. These speed reducers are made in ratings of ½ hp to 20 hp and in 12 ratios. Rockwood Pulley Mfg. Co., 20 Crosby St., New York, N. Y.

For more information—
Circle 25, inside back cover

Mechanical Limit Stop

Contained in a Size 11 Synchro housing, this miniature unit is suited for direct incorporation into servo systems, without the need for special mounting hardware. The unit is of the lead screw-type, permitting a total travel of 40 revolutions. It can be continuously set over its full range without removal from the mechanical system. Leaf spring stops protect components and gears from jarring halts. Reeves Instrument Corp., 207 E. 91 St., New York 28, N. Y.

For more information—
Circle 26, inside back cover



Clip for Shelving

This one-piece clip can fasten shelving on both the sides and the back of a cabinet. When used to fasten the back of the shelf, the unit is snapped up through a slotted hole in the bottom flange of the shelf. The leg on the back of the clip springs over the slot to lock the clip in position. A special projection on the clip is then simply pushed into a hole on the back wall of the cabinet.

Applied as a fastener for the sides of the shelf, the same unit is snapped down through a slot in the side of the cabinet. The shelf, with a slotted hole, then slips down over the special projection on the slip. With the four clips in place, the shelf is first engaged at the rear, then lowered down in the front completing the entire operation. Tinnerman Products, Inc., Cleveland, Ohio.

For more information—
Circle 27, inside back cover

Cups and Packings

Cups and packings made of elastomer impregnated mechanical leather are preformed in special dies to produce a sharp heel. This is said to eliminate operational stress and flexing that conventional cups undergo.

Tests with cups of conventional design and the new molded design run in a hydraulic cylinder for 3000 cycles at 6000 psi showed marked wear and distortion at the heel of the former, while the latter showed little, if any, wear, according to the manufacturer. Chicago Rawhide Mfg. Co., 1301 Elston Ave., Chicago 22, Ill.

For more information—
Circle 28, inside back cover

Bearings With Non-Metallic Outer Races

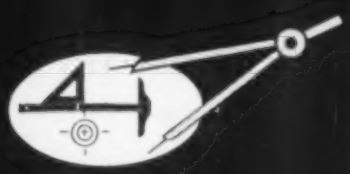
Stud, bore, flange, and special bearings can now be supplied with nylon, rubber, or laminated phenolic tires, serving to reduce noise factors during operation. Outer race materials can be molded or press-fit to the basic

CONTINUED ON PAGE 234

USING

DU PONT ELASTOMERS

neoprene · Hypalon®



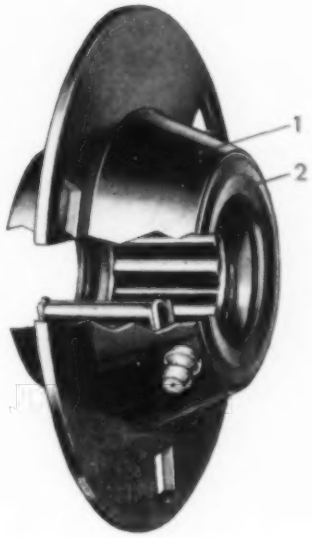
in design

Bearing gives smoother performance, longer life because of neoprene housing and shaft seal

Convertible top coated with HYPALON resists sunlight, weathering, discoloration, cracking

When one large automotive manufacturer wanted a convertible top for new models that would give longer wear, HYPALON was specified as the coating over the canvas body. This newest Du Pont synthetic rubber was chosen because it will not crack or harden under prolonged exposure to weather, and is exceptionally resistant to the effects of sunlight. HYPALON can also be compounded in a wide range of stable colors . . . important as a styling consideration in the competitive automotive industry.

HYPALON offers almost unlimited industrial design possibilities. It is particularly adapted to applications where exceptional ozone resistance and resistance to oxidizing chemicals are important. HYPALON also shows unusual resistance to hardening at elevated temperatures (250°-350° F.). For full information on the useful properties of HYPALON for design, just mail coupon below.



1. Neoprene housing permits shaft alignment changes.
2. Neoprene seal retains lubricant, seals out dirt.

Flexible neoprene housing on roller bearing adapts to instant changes in shaft alignment

This new cartridge type roller bearing, introduced by the Rollway Bearing Company of Syracuse, N. Y., is designed for farm and industrial materials handling equipment. It is made in shaft sizes from 1/2 to 1 7/16 inches. The bearing's flexible neoprene housing adjusts to shaft alignment changes caused by vehicle movement, or shifts in load distribution on pulleys attached to the shaft. It permits misalignment between shaft and bolting flange of at least one degree. This adds considerably to bearing life and cuts fatigue on walls or panels to which the flange is mounted.

Rollway specified neoprene for the housing and shaft seal because it *keeps* its flexibility despite hard wear and extremes of temperature and humidity. Neoprene was also chosen for its outstanding resistance to oil and grease and the abrasion of dirt and grit. Regular bearing lubrication has no effect on the neoprene seal.

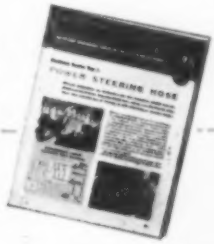
It's this *balanced combination* of properties that makes neoprene so useful for applications where severe service conditions would ruin ordinary rubber or less resilient materials. Neoprene resists acids, oil and grease, abrasion, sunlight and weathering. Mail coupon below for details on how neoprene's many useful properties have been designed into many industrial products, and how they can work for you.

DU PONT

REG. U. S. PAT. OFF.

HYPALON *is a registered trademark of E. I. du Pont de Nemours & Co. (Inc.)*

BETTER THINGS FOR BETTER LIVING . . . THROUGH CHEMISTRY



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E. I. du Pont de Nemours & Co. (Inc.)
Elastomer Chemicals Dept. PE-7
Wilmington 98, Delaware

Name _____
Firm _____
Address _____
City _____ State _____

steel outer race and the resultant combination affords wear resistance in addition to silent operation. General Bearing Co., Inc., 47 Roselle St., Mineola, N. Y.

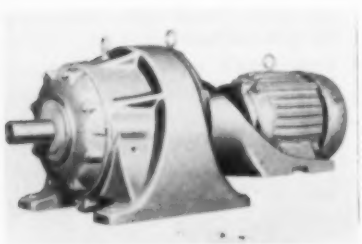
For more information—
Circle 29, inside back cover

Ball and Socket Joint

A ball and socket joint has a socket of polyethylene molded within a metal housing. The nickel-plated brass ball and arm assembly are housed in an aluminum casing. The joint is being manufactured on a custom basis in several sizes and styles. Telex, Telex Park, St. Paul 1, Minn.

For more information—
Circle 30, inside back cover

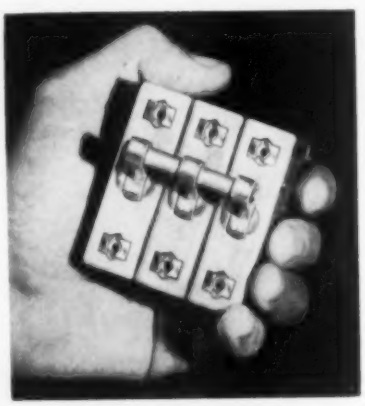
ELECTRICAL POWER, CONTROL



Flexible Reduction Drive

A packaged power unit meets JIC requirements for operations that require a standard NEMA motor mounted separate from the gear unit. It uses a heavy duty, cast-iron motor support to provide access to the motor mounting and coupling and is available for a variety of mounting positions including wall, ceiling, shaft-up or shaft-down. Double reduction gears are in ratios that range from 7.6:1 to 47:1. Speed ranges are from 37 to 280 rpm; hp ratings are from 1 to 30. U.S. Electrical Motors Inc., Box 2058, Terminal Annex, Los Angeles 54, Calif.

For more information—
Circle 31, inside back cover



Interchangeable Circuit Breaker

A circuit breaker line designated as Series AM17 is interchangeable for 400-cps, a-c and d-c use. Although manufactured in single-pole form only, these breakers can be linked with others to make two- or three-pole units. The only operating connection necessary is a tie rod through the breaker handles; electrical tripping of one breaker causes simultaneous tripping of the other connected breakers. Kits of inter-connecting parts may be supplied for ganging the breakers into two- or three-pole assemblies.

The unit which operates on the hydraulic-magnetic principle, does not require de-rating for either temperature or vibration conditions. Heinemann Electric Co., 725 Plum St., Trenton 2, N. J.

For more information—
Circle 32, inside back cover

Time Switches

Carrying a momentary inrush surge of more than eight times their normal amperage rating, these tungsten-rated

time switches are designed to handle heavy-duty incandescent lighting loads. Incorporated in these units are contacts with increased surface to provide positive contact, better conductivity, and freedom from welding. Spring brass U-beam blades are used in a mechanism which is said to produce four times more switching power.

They have a black-on-yellow dial, synchronous timing motor, 5¼ x 3 in. knockouts, snap-out mechanism, and manual control with automatic reset. International Register Co., 2624 W. Washington Blvd., Chicago, Ill.

For more information—
Circle 33, inside back cover

Universal Power Module

Besides modular construction, this power unit features transistor-equipped circuits. By eliminating vacuum tubes and controlling the stepper drive duty cycle, power consumption has been greatly reduced. Heat dissipation is said to be held to a minimum.

Input power may vary from 50 to 400 cps, which makes the unit applicable for field or airborne power supply applications. Switch life has been increased by a factor of three by controlling the stepping switch drive. An improved amplifier design

CONTINUED ON PAGE 236

IF IPC designed these Oil Seals for your application, you can be sure that every one will give the maximum in service. That's "custom control" . . . IPC's watchword in packings or oil seal manufacture.

Specialized engineering, custom compounding, rigid manufacture and 100% inspection guarantee such results!

Your oil seals require a *custom* approach since different applications impose different demands on oil seal performance. IPC will help you solve your problems at the design stage . . . follow through by controlling manufacture and inspection. Take your toughest "nut" to IPC.

IPC

Packings
Oil Seals
Precision Molding

INTERNATIONAL PACKINGS CORPORATION

Bristol, New Hampshire

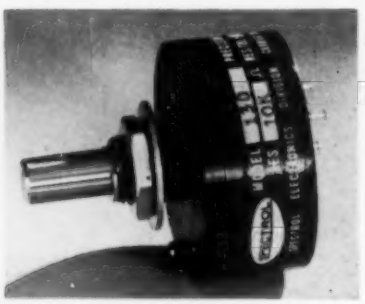
BONDED BY IPC

1. Bonded Washer Seal Double Lip Wiper
9. Bonded Case Seal Straight Lip With Garter Spring
2. Bonded Case Seal Double Lip Wiper
10. Bonded Case Seal Limited Contact Lip With Garter Spring
3. Bonded Washer Seal Straight Lip
11. Bonded Case Seal Straight Lip Thin Rind Type
4. Bonded Washer Seal Limited Contact Lip
12. Bonded Case Seal Limited Contact Lip Thin Rind Type
5. Bonded Washer Seal Straight Lip With Garter Spring
13. Rubber Covered Bonded Case Seal Straight Lip
6. Bonded Washer Seal Limited Contact Lip With Garter Spring
14. Rubber Covered Bonded Case Seal Limited Contact Lip
7. Bonded Case Seal Straight Lip
15. Rubber Covered Bonded Case Seal Straight Lip With Garter Spring
8. Bonded Case Seal Limited Contact Lip
16. Rubber Covered Bonded Case Seal Limited Contact Lip With Garter Spring

P4

gives increased operational freedom from spurious hum and noise in input signals. Freedom from line transients and radio noise when steppers are operated is provided by a new stepper drive design. The standard 3½ in. x 19 in. x 12 in. rack and panel is designed to fit all racks. Electro Instruments, Inc., San Diego, Calif.

For more information—
Circle 34, inside back cover



Single-Turn Potentiometer

A precision 1⅝ in. dia single-turn potentiometer will operate in a temperature range of −55 C to 85 C. The standard linearity tolerance is ±0.5%. The unit has a standard resistance range from 10 to 30,000 ohms, with a standard tolerance of ±3%. The model is supplied with standard threaded bushing, sleeve bearing-type mount. Spectrol Electronics, 1704 S. Del Mar Ave., San Gabriel, Calif.

For more information—
Circle 35, inside back cover

Transistor-driven Switching Device

A transistor-driven unit is actuated as a function of the input signal frequency. The switch contacts close whenever the input signal frequency is 380 cps or greater. If the signal frequency drops below 380 cps, the contacts will reopen. The switch is single-pole double-throw with contacts rated at 2 amp at 28 v d-c.

Accuracy of the unit is 0.1% over the entire environmental range. The unit is designed to withstand 30 G shock and 10 G vibration from 10 to 2000 cps. Recommended operating temperature limits are −55 C to 85 C. The only input power required is 115 v, 400 cps, a-c. Atlas Electro-Mechanical Laboratories, Inc., 14734 Arminta St., Panorama City, Calif.

For more information—
Circle 36, inside back cover

Torque Motor

A torque motor designed for tape recorder take-up reel drive is capable of withstanding stall currents continuously. It has a nearly linear speed-torque curve to stall. No-load speed is 2150 rpm; weight 5¼ lb. Dalmotor Co., 1375 Clay St., Santa Clara, Calif.

For more information—
Circle 37, inside back cover

Momentary Contact Switch

This momentary contact switch has a normal life under pilot load in excess of 20 million cycles. Rating of the normally "off" switch is 15 amp, 125 or 250 v, 1 hp, 120 or 240 v a-c. The d-c rating is 1 amp, 125 v; ¼ amp, 250 v. The unit may be used either as an actuating or safety-limit switch. Under full load, tests have shown the switch to have a normal life in excess of 1.5 million cycles. McGill Mfg. Co., Electrical Div., Valparaiso, Ind.

For more information—
Circle 38, inside back cover

Pushbutton Switch

A dust and vibration-proof, push-button industrial switch with a rating of 6 amp, 125 v; 3 amp, 250 v is standard with 6 in. wire leads. The switch has soldering lugs or screw terminals. Push button is ⅜ in. dia. and finished in nickel. Other models include a three-way type of 6 amp, 125 v, and a two-circuit type for controlling either of two circuits. It has no off position and is rated at 6 amp, 125 v. McGill Mfg. Co., Inc., Valparaiso, Ind.

For more information—
Circle 39, inside back cover

Capacitor Motor

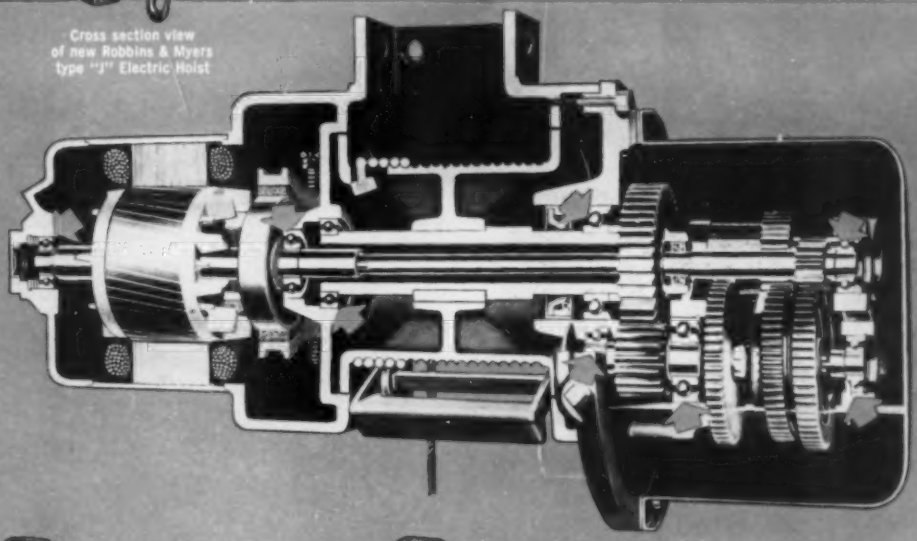
A 19-frame, two-pole, permanent-split capacitor motor rated 1/40 or 1/20 hp is designed primarily for small business machine applications, such as calculators and adding machines. The new motor will operate on 115 or 230 v; single phase, 50 or 60 cps, and has a speed of 3200 rpm. It will run either clockwise or counterclockwise and can be made reversible.

Advantages of the new motor are its reduced maintenance due to absence of brushes and governors, and virtual elimination of radio and tele-

CONTINUED ON PAGE 238

9 PROVEN POINTS OF QUALITY ENGINEERING IN A LOW-COST HOIST

Cross section view of new Robbins & Myers type "J" Electric Hoist



The Fafnir 9100K Series ball bearing is designed basically for applications where housing diameters are restricted and maintenance of relatively large shaft diameters is essential. Available with seals or shields.

The Fafnir 200K Series ball bearing is well suited for applications requiring light to moderate loads combined with relatively high speeds. Available with seals, shields, and snap rings in various degrees of precision and retainer construction.

WHEN the design engineers of Robbins & Myers were asked to develop a low-cost electric hoist that would measure up to R & M standards of quality, they made good use of Fafnir Ball Bearings. They specified them to insure precise alignment of parts, conservation of power, minimum maintenance, reserve capacity for long life. In three critical locations they specified Fafnir Plya-Seal bearings — the bearings that provide superior retention of lubricant and positive protection against contaminants. With these and other construction features, they came up with the design of the new Robbins & Myers low-cost, "J" hoist, *quality engineered throughout.*

Fafnir is a supplier of ball bearings for leading industrial hoists, hoist trucks, and hundreds of other industrial machines and equipment where ball bearing advantages improve performance and prolong service life. In case after case, the choice of Fafnir Ball Bearings is influenced by the Fafnir "attitude and aptitude"—a way of looking at bearing problems from the designer's viewpoint and the ability to supply the right ball bearing to fit the need. Perhaps these attributes can help you solve a bearing problem. The Fafnir Bearing Company, New Britain, Conn.

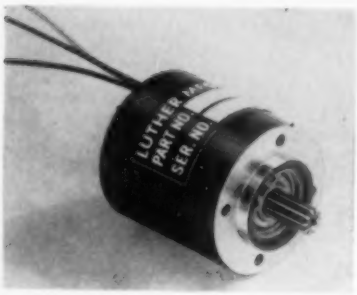
FAFNIR

BALL BEARINGS

MOST COMPLETE LINE IN AMERICA

vision interference. It has a 3-in. dia (2⅞ in. across the flats), while length of the 1/40 and 1/20 hp ratings is 4⅛ and 5 in. The open, self-ventilated motor can be mounted rigidly, or provided with rubber rings for resilient mounting. Bearings are of the self-aligning, oil-impregnated porous-bronze type. Rotors and end brackets are die-cast. Westinghouse Electric Corp., P. O. Box 2099, Pittsburgh 30, Pa.

For more information—
Circle 40, inside back cover



Hysteresis Synchronous Motors

Synchronous motor characteristics may be obtained in a Size 10 frame, 1 in. OD, for applications requiring constant running speeds such as computer mechanisms, timing devices, programmers and for relay-operated control motor applications. Available in 8000 and 12,000 rpm models; single-phase and three-phase; 26 and 115 v.

Motors are constructed with homogeneous rotors and stators featuring constant torque independent of rotor position. Luther Manufacturing Co., 7312 Varna Ave., N. Hollywood, Calif.

For more information—
Circle 41, inside back cover

Transistor-equipped Power Inverters

This 50 va, d-c to a-c transistorized inverter is designed for gyro motor excitation. The size is 2⅜ x 1⅞ x 3⅜ in. and the weight is 15 oz. Input is 26 to 30 v d-c; output is 115 v a-c, 400 cps. The unit is short circuit-proof and the minimum maintenance free life is estimated at over 5000 hr. Modern Industries, Inc., Santa Monica, Calif.

For more information—
Circle 42, inside back cover

Tubeless d-c to a-c Power Supplies

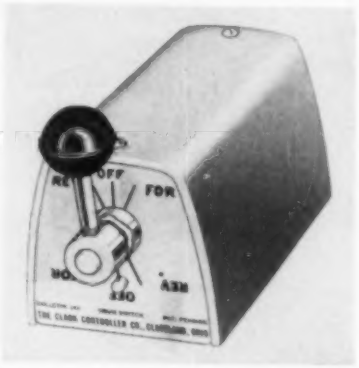
A series of lightweight, compact, d-c to a-c power converters for battery-powered portable, aircraft, and vehicular electronic equipment produces up to 250 va from 28 v d-c input; custom units are available to 2 kva.

Units can be made to meet MIL specifications, and can be as compact as ⅓ cu in. per va and as light as ½ oz per va. UAC Electronics, 143 E. 49 St., New York 17, N. Y.

For more information—
Circle 43, inside back cover

Drum Switches

Used for reversing across-the-line starting of small conveyors, shop tools, door operators, oil burners, and other applications for small a-c or d-c motors.



These units permit instant reversing of any small standard single phase a-c motor. In standard form the switches are furnished in NEMA 1 enclosures for surface or flush mounting. Horsepower ratings are ¼ hp for d-c motors, 1 hp for 115 v single-phase a-c motors, 1½ hp for 230 v, single-phase a-c motors, and 2 hp for 220-550 v, two or three-phase a-c motors. Clark Controller Co., Cleveland, Ohio.

For more information—
Circle 44, inside back cover

Rotary Selector Switch

Units have color-coded leads and are rated at 50 ma at 300 v a-c or d-c, and 500 ma at 30 v a-c or d-c. Entire switch is encapsulated with the exception of bushing and shaft. Body diameter is 29/32 in.; body length 1⅛ in. max. Clarostat Mfg. Co., Inc., Dover, N. H.

For more information—
Circle 45, inside back cover

Miniature Ceramic Switch

A ceramic switch can be "ganged" with up to eight decks. Occupies less than 1½ sq in. of panel space. This miniature switch contains up to 18 positions on a single wafer. Solid silver alloy contacts, rotors, and slip

CONTINUED ON PAGE 240

NEW

KAYDON THIN SHELL NEEDLE BEARINGS

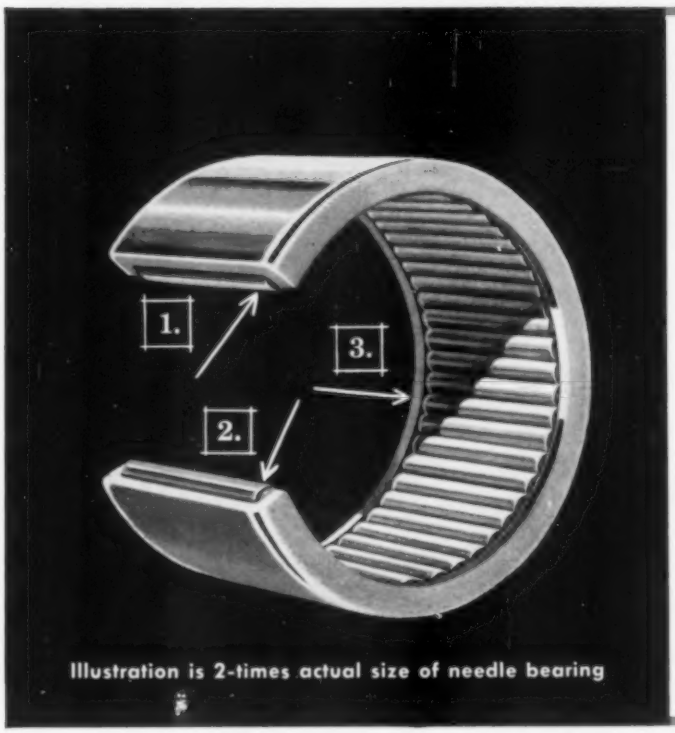
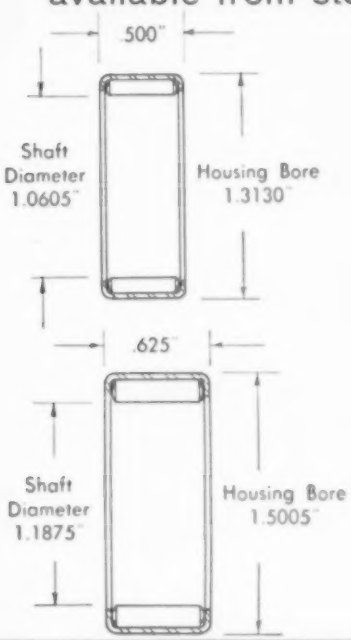


Illustration is 2-times actual size of needle bearing

Two standard sizes available from stock



You get these Kaydon design advantages:

1. Greater effective length needle rollers for MORE CAPACITY (41% on ½" width) . . . LONGER LIFE (2.8 times as much on ½" width) 2. Simplified construction that SAVES you money 3. Pre-packed lubrication that SAVES assembly time.

These new thin-shell bearings were developed with the co-operation of the FORD MOTOR COMPANY for use in FORD-O-MATIC and MERC-O-MATIC automatic transmissions

Kaydon's new thin-shell needle bearing gives more of everything — *more economy . . . more capacity . . . plus longer life* than any other comparable bearing. That's because of Kaydon's greater effective length of spherical end rollers.

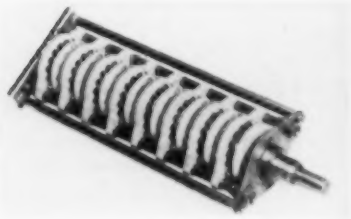
This new bearing is ready for you right now from stock in two standard sizes (illustrated). Other sizes will be available later.

For complete specifications, ask for Data Sheet No. K562 — write, call or wire Kaydon of Muskegon.

THE KAYDON ENGINEERING CORP.

MUSKEGON • MICHIGAN

All types of ball and roller bearings — 4" inside diameter to 124" outside diameter . . . Taper Roller • Roller Thrust • Roller Radial • Bi-Angular Roller • Spherical Roller • Needle Roller • Ball Radial • Ball Thrust Bearings



rings provide low and uniform contact resistance. Ceramic parts are silicone impregnated to function under extreme humidity. Flashover voltage at 60 cps is 1000 v peak; current carrying capacity is 2 amp. Daven Co., Livingston, N. J.

For more information—
Circle 46, inside back cover

Lever-Actuator Mechanism for Subminiature Switches

Designed to provide operating force even lighter than standard subminiature switches, the ATM-1 actuator requires only 40 g max to operate this snap-action switch. When used with this basic switch, pre-travel is $\frac{1}{8}$ in. and over-travel is $\frac{1}{32}$ in. approximately. These switches are manufactured to meet commercial standards; also for high-temperature use up to 275 F. Unimax Switch, Ives Road, Wallingford, Conn.

For more information—
Circle 47, inside back cover

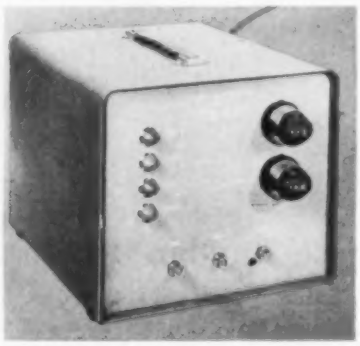
Low Level Digital Millivoltmeter

Instrument makes possible measurement of low level d-c voltages from thermocouples, strain gages, and transducers and displays this information in 1 in. high self-illuminated numerals.

The unit ranges of 0 to ±9.999 mv and ±10.00 to ±99.99 mv are automatically selected. It has sensitivity of three digits and an accuracy of ±0.1% of full scale on each range.

An internal standardization device automatically maintains the potentiometer circuit reference voltage at the correct value by automatically standardizing against internal, unsaturated cadmium standard cells. Non-Linear Systems, Inc., Del Mar, Calif.

For more information—
Circle 48, inside back cover

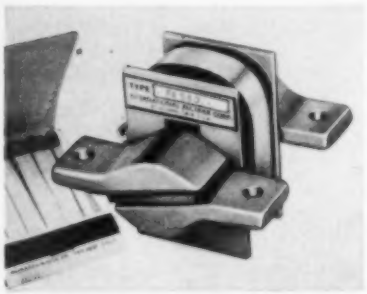


Automatic Gaging and Tool Control System

Automatic gaging, sorting, or size control is accomplished with an electronic control system consisting of a displacement transmitter and a limit controller. An electronic null-balance system gives high speed and stable accuracy of 0.00001 in. With the transmitter mounted in a suitable gaging fixture, limit points or tolerance values are pre-set on digital dials. Controller makes decision in 0.05 sec and positions output relays which can be used to actuate reject or marking devices, sorting gates, or alarms.

The system is adaptable to machine tool control to produce pieces of predetermined size. Inputs can be programmed from punched cards or other data storage devices to achieve completely automatic control of complex machining processess. Daytronic Corp., 216 S. Main St., Dayton 2, Ohio.

For more information—
Circle 49, inside back cover

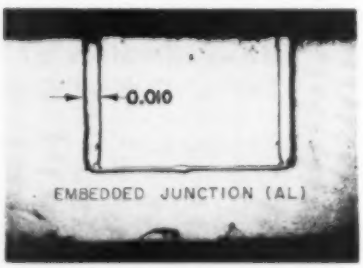


Paralleling Reactors

Designed to insure equal distribution of current loads to germanium rectifier junctions operating in parallel this unit makes possible very heavy current installations of germanium rectifiers formerly limited by the difficulty of matching junctions. Reactors are rated at 580 amp rms for 50 C rise with normal convection cooling. When air-cooled, their rating increases to 820 amp.

A second reactor in this series is rated for 50 C rise at 2500 amp rms, air-cooled. International Rectifier Corp., El Segundo, Calif.

For more information—
Circle 50, inside back cover



Thermocouples for In-Wall Applications

These thermocouples measure temperatures at in-wall locations, employing a technique of embedding ribbon junctions in weld nuggets at selected

CONTINUED ON PAGE 242

STOP Aluminum Corrosion
INSURE Paint Adhesion
with TURCOAT 4178

THE QUICK-FIXING ALUMINUM SURFACE CONVERSION COATING

Proved by continuous 800 hour salt spray test!

HERE'S UN-RETOUCHED PROOF! Lower portion of aluminum coupon was coated with Turcoat 4178. Upper portion was not coated. Entire coupon was then subjected to 800 hour salt spray test. Note that uncoated portion has been virtually destroyed while Turcoated portion shows only superficial blemishes.

only* PAINT-GRIPPING, CORROSION-RESISTING TURCOAT 4178 *offers you all these plus values!

QUICK FIXING—Turcoat 4178 coatings become non-smearing immediately upon withdrawal from processing. Parts can be handled freely *while still wet* without danger of smearing or streaking coating.

MEETS MIL-C-5541—Used by aluminum fabricators the nation over for government and non-government jobs involving aviation, building parts, household appliances, luggage, ornamental aluminum, aluminum foil, irrigation pipe, automotive and truck parts and bodies, etc.

EASY TO USE—Applied by spray, dip or hand methods. Requires no heating . . . no electric current. Easily controlled by mere pH adjustment.

UNIFORM—No light tell-tale untreated sections around welds, corners or holes.

ECONOMICAL—Used at low concentrations. Extremely long-lived. Will accept tremendous contamination without loss in efficiency.

COLORS—Available in gold iridescent or natural aluminum.

FREE **SHOWING—TRAINING MOVIE!**
"ALUMINUM FINISHING"

New full-color film visually demonstrates every aspect of aluminum finishing from laboratory theory to authentic production-line techniques filmed on-the-spot during mass production. If your plant or technical group is interested, write today for full details without cost or obligation.

WRITE FOR TECHNICAL DATA . . . FREE! 4 pages full of technical information on Turcoat 4178, the quick-fixing aluminum conversion coating. Write for your *free* copy, without obligation . . . *today!*

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TITLE _____
FIRM _____
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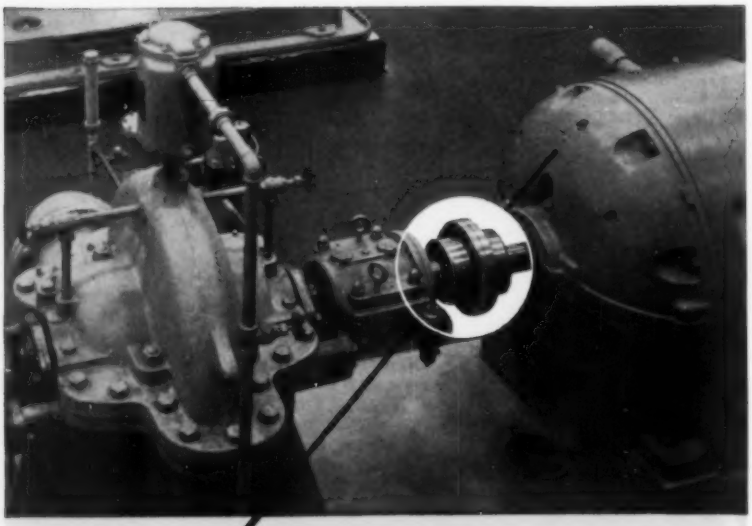
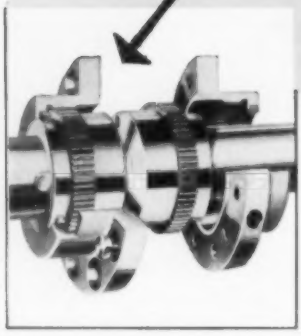


Waldron couplings on boiler feed pumps

WALDRON

flexible couplings...



USED IN HUNDREDS OF DIFFERENT APPLICATIONS BUT ALWAYS FOR THE

same 3 reasons

1 STRENGTH — Hubs and cover sleeves for sizes 1¼ A through 7A are machined from tough steel forgings. Hubs are keyed to the shafts. The two one-piece cover sleeves function as a single, rigid unit serving as a floating connecting link between the hubs. High strength of forgings makes possible a very compact coupling with low rotating inertia.

2 RELIABILITY — There are no flexible parts to bend or break and the coupling is dust, moisture, and oil tight. Patented Walflex seal is positioned where centrifugal force is least. Clearance between teeth in hubs and sleeve is engineered so that an oil wedge always separates them, taking the wear.

3 SERVICE — Plenty of rough bore couplings, already assembled—on the shelf for *immediate* delivery. Finish bored standard couplings shipped to meet customers' schedules. We are geared up to give you realistic delivery on *any* type of couplings.

Ask for Catalog 57

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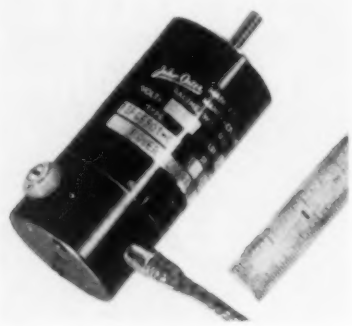
NEW BRUNSWICK, NEW JERSEY

Representatives In Principal Cities

Export Agents—Frazar & Co., New York, N. Y.

depths, in ¼ in. threaded plugs of steel and aluminum. Detroit Controls Corp., 1650 Broadway, Redwood City, Calif.

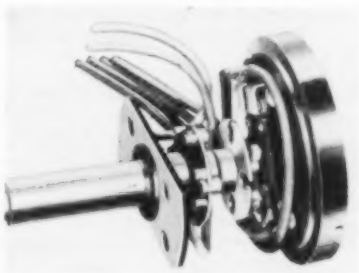
For more information—
Circle 51, inside back cover



High Output D-c Generator

A permanent magnet d-c generator has a 10 w output at 10 v min d-c at 8000 rpm continuous duty with 1000 hr life and 25 C max temperature rise. Diameter is 1.25 in., length 2.6 in. and weight 7 oz. The device has 3 in.-oz input torque and is face mounted. Designed for any d-c generator application requiring exceptionally high d-c output. John Oster Mfg. Co., 1 Main St., Racine, Wis.

For more information—
Circle 52, inside back cover



Speed Detector For Flange Mounting

A self-contained dust-tight unit provides its own shaft mounted in ball bearings. The shaft can be coupled by any normal method to the shaft of the equipment to be protected or controlled.

This unit can incorporate almost any required combination of sensing switches to detect overspeed and

(Continued on page 245)

As filled capsules are inspected at Abbott Laboratories, North Chicago, Illinois, the girl suits the speed of the Jeffrey feeder to her requirements with the hand rheostat.

FLOW CONTROL is possible within wide limits, simply by changing feeder's amplitude of vibration.

A way to do what "can't" be done...
JEFFREY Vibrating Feeders

Jobs once considered too costly, too hazardous, or just plain impossible are being done with Jeffrey electric vibrating feeders . . . handling a tremendous variety of materials, densities from 4 to 400 pounds per cubic foot, one micron in size to four-foot cubes, a few ounces to 2,000 tons per hour.

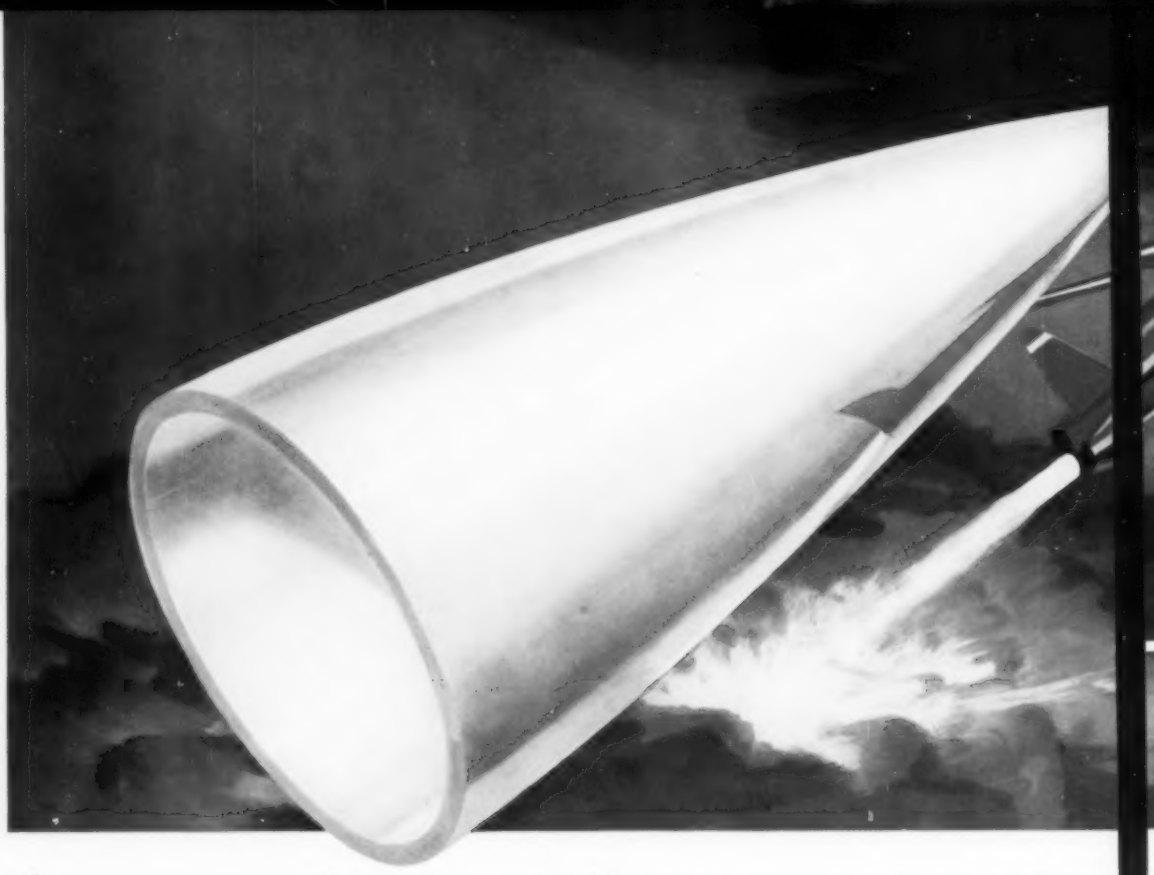
With Jeffrey feeders, the operator has instant and absolute control over the flow of material. This control may be manual or automatic, depending upon equipment that follows, to insure optimum loading. Thus a plant and its workers can produce at top efficiency.

Jeffrey engineers are expert in applying vibrating equipment to all types of processes, and are available to help solve your feeding and conveying problems. Catalog 870 describes these feeders. The Jeffrey Manufacturing Co., 788 North Fourth St., Columbus 16, Ohio.

CONVEYING • PROCESSING • MINING EQUIPMENT . . . TRANSMISSION MACHINERY . . . CONTRACT MANUFACTURING

JEFFREY

CORNING



A new wide-range basic material

PYROCERAM is an entirely new basic material made from glass. We think it is the most important technological break-through ever made in glass research.

Actually, PYROCERAM is not just one material, but a whole new class of materials that can be mass-produced in any shape glass can be. We've already experimentally melted over 400 different kinds with widely varying properties. And we'll continue to make many more as our development work progresses.

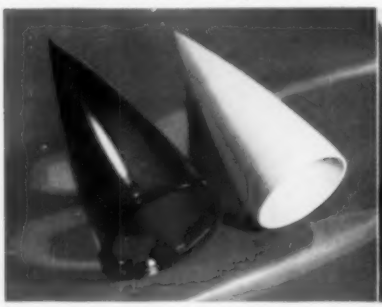
Uses? One we're actively investigating right now is PYROCERAM for the conical noses of guided missiles—called radomes. We've developed a PYROCERAM that will stand up in flight at the unbelievable speeds missiles will soon be traveling. Future uses for PYROCERAM are limited only by the ingenuity of American industry.

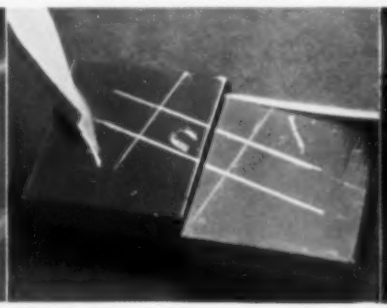
PYROCERAM starts out as a glass. But it isn't really a glass at all when we get through heat-treating it by a special technique we've developed. Because of a unique

The sky's *not* the limit! Heat-treating changes this PYROCERAM from a glass into a new basic material of unlimited usefulness (below, nose of a guided missile). PYROCERAM can be mass-produced to close tolerances. It can be drawn into sheets, rods or tubing; even blown, cast or pressed.

Harder than steel. Tests show some kinds of PYROCERAM are 27 times more resistant to sandblasting than glass, and are harder than hardened steel (below, PYROCERAM scratches steel and brass). This hardness suggests such uses as special cutting tools, bearings and brake linings.

Still rigid at 2,200°F. This PYROCERAM isn't deformed by heat that warps steel and melts copper. And we can tailor the coefficient of expansion of this material . . . make kinds that expand, shrink or remain the same size when heated. Indicated uses: cooking pans to blades for turbine engines.





...can do almost anything

pyroceram*

* CORNING'S TRADEMARK FOR ITS CRYSTALLINE MATERIALS MADE FROM GLASS

developed by Corning research

combination of ingredients in the original glass formula, heat changes the actual molecular structure of the glass. It becomes PYROCERAM – a material extremely hard, lightweight and non-porous.

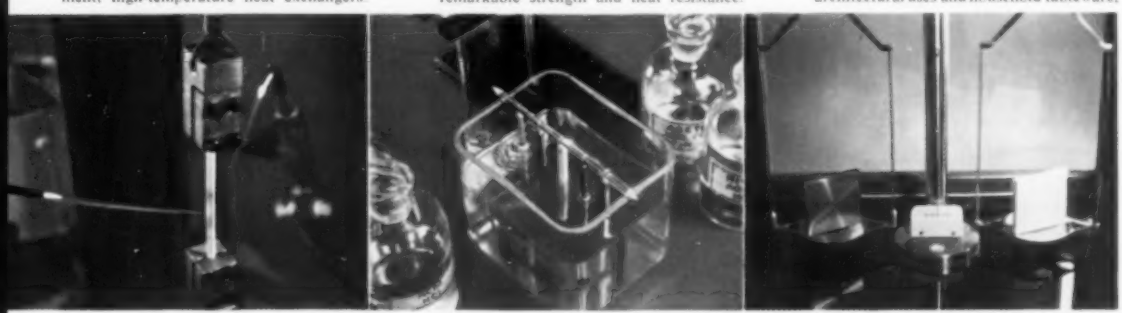
PYROCERAM can be made white and in color. We've even made some kinds that are transparent. Some have superb chemical and electrical properties; some kinds are stronger than bronze; some aren't deformed by temperatures that warp stainless steel.

Right now at Corning our scientists and engineers are looking into dozens of possible uses for PYROCERAM. And we have just dedicated the new Eugene C. Sullivan Research Laboratories, which will enable us to broaden all our activities in PYROCERAM research and glass research in general. For the latest information on PYROCERAM and our thousands of other glass products, write Director of Sales, Corning Glass Works, 7 Houghton Park, Corning, New York.

Stronger than bronze. Some kinds of PYROCERAM have greater tensile strength than cast iron, brass and bronze... keep this strength under the intense heat of two acetylene torches. This makes it a good bet to see service as pipe for processing equipment, high-temperature heat exchangers.

Stands up to corrosive chemicals. Here's a PYROCERAM that's unharmed by an acid solution that severely attacks steel, aluminum, copper and magnesium. PYROCERAM also has great alkali resistance. And it combines chemical resistance with remarkable strength and heat resistance.

As lightweight as aluminum... which means that PYROCERAM may some day be used as the "skin" of supersonic aircraft and other air-borne parts. PYROCERAM is also a beautiful material–smooth as glass, easy to keep clean. It should be ideal for architectural uses and household tableware.



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with glass

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CORNING, NEW YORK

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inch for inch

and

ounce for ounce

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find out how

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can match your specs-
best operate your design
the way you designed it

SYNCHRON synchronous motors operate smoothly, evenly in any position; at temperatures from —40° to +140°F.; start instantly under load; pull up to 20 in. oz. at 1 RPM. Available in 42 speeds from 0.8 RPM to 600 RPM.

"Workhorse of the industry"

5 Quality Facts — why Synchron Timing Motors are built better to run better

MACHINED TO FINE-WATCH PRECISION — Tolerances as close as .0001 are standard. Strict attention given to quality control in all materials and manufacturing; insure greatest accuracy, dependability; give continuous, trouble-free service.

LIFETIME LUBRICATION — All bearings lubricated in sealed-in Dow-Corning Silicone lubricant, provides lifetime lubrication, stops noise and wear, assures high operating efficiency during motor lifetime from —40° to +140°F.

PRE-TESTED CAPACITY — 51 rigid laboratory tests give performance-proof of top power and efficiency. Tests conducted in temperatures ranging from 40° below zero to 140° above zero F.

STEEL PINIONS AND BRASS GEARS — For quiet operation, sustained accuracy, long life — all steel pinions and rotor shafts, high quality, polished brass engaging gears. Perfect matching of gear teeth stops vibration, assures instant delivery of top power and speed.

FAMOUS HANSEN PATENT — the 100% guarantee of Synchron Quality. Every motor designed, built, and inspected to produce sustained torque power to top rated capacity.

SYNCHRON
5 quality motors . . . by Hansen

STANDARD TIMING MOTOR (8 IN. OZ.) — Compactly built to space saving dimensions, with rotor and coil packed in a sturdy, hand-sized case. Used in timing devices and controls of all types. Guaranteed torque 8 in. oz. at 1 r.p.m.

HI-TORQUE TIMING MOTOR (20 IN. OZ.) — There's big power packed into this versatile timing motor. One year guarantee. Dependable, accurate, trouble-free. Guaranteed torque 20 in. oz. at 1 r.p.m.

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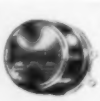
HANSEN MAGNA-TORC DC MOTOR — Designed for aircraft instruments and radio controls. Armed Forces applications have proved its top performance world-wide under all operating conditions. Easily adapted to commercial uses.

Hansen engineers will gladly provide you with confidential assistance
on special timing motor applications

SYNCHRON TIMING MOTORS IN ALL SPEEDS AVAILABLE FOR PROMPT DELIVERY

SYNCHRON®



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HANSEN MFG. CO., INC.
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PRINCETON 5, INDIANA

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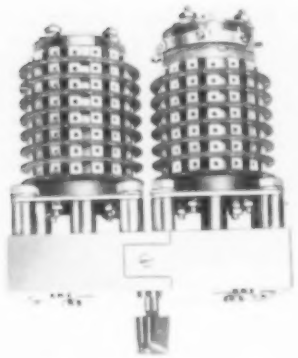
The Fromm Co., 5150 W. Madison St., Chicago, Ill.; R. H. Winslow Assoc., 123 E. 37th St., New York, N. Y.; Electric Motor Engineering Inc., Oakland, Calif.; H. C. Johnson Agencies, Inc., Rochester, Buffalo, Syracuse, Binghamton, New York.

underspeed in a narrow or wide range. Once detected, the speed can be controlled by any practical circuitry. It is particularly adaptable for use on conveyor and similar types of drives to indicate slippage or to actuate magnetic clutches. It also provides a method of shifting multi-speed transmission gears. Torq Engineered Products, Inc., 32 W. Monroe St., Bedford, Ohio.

For more information—
Circle 53, inside back cover



Rotary Switch Assembly

Gear-operated pairs of 16-position, 12-section rotary multiple switches double the number of electrical circuits that can be controlled by a single knob. This type of assembly keeps switch length to a minimum and, along with detent mechanism, assures positive positioning of rotors at each 22½° angle of rotation of the switch handle.

Electrical rating is 5 amp, 125 v a-c at 0.80 power factor. Contacts are non-shorting (break-before-make). The geared-pair assembly has 16 handle positions, 15 on and 1 off position. Electro Switch Corp., Weymouth 88 Mass.

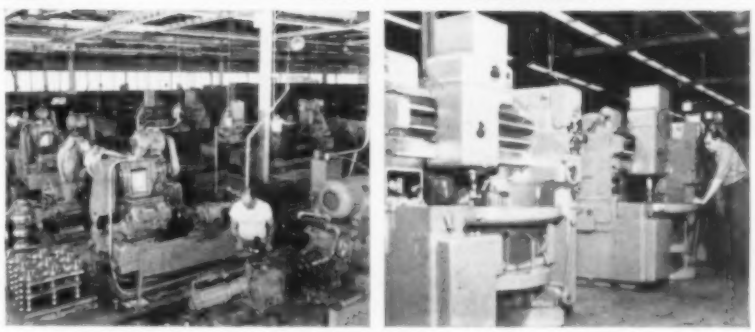
For more information—
Circle 54, inside back cover

Insulated Terminals

Subminiature terminals range from 0.093 in. dia. and from 0.250 in. to 0.5 in. overall height, depending on whether they are stand-offs or feed-throughs. Such terminals simply press-fit into chassis holes by means of an insertion tool and drill-press equip-

(Continued on page 248)

"FAIRFIELD for FINE GEARS"



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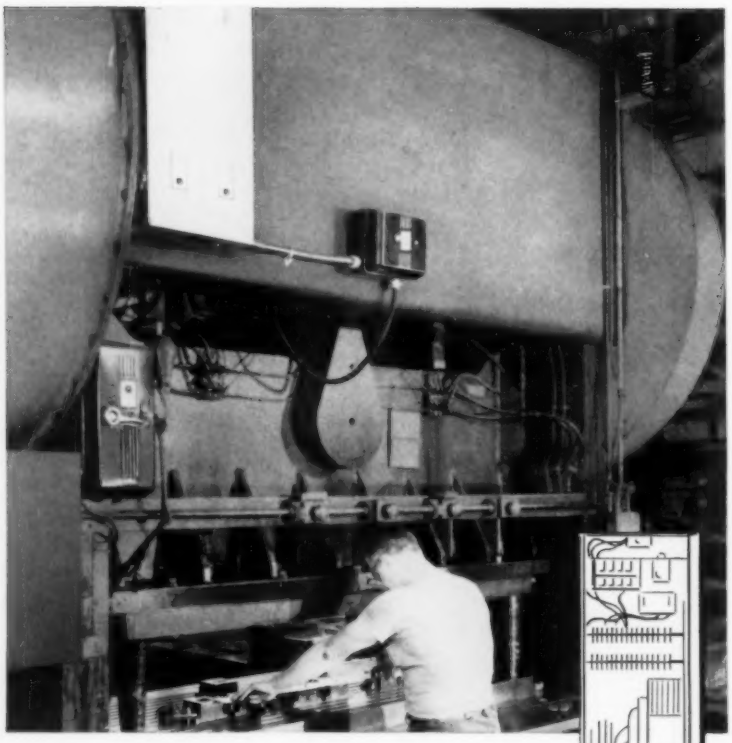
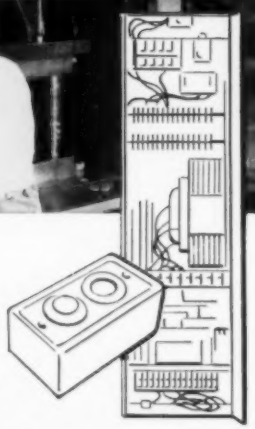




DynAC® cuts Press Stopping Time 95%

The eight minutes it previously took to stop the heavy flywheel on this press has been cut to an amazing *24 SECONDS* with Westinghouse DYNAC.

This press is now getting the fastest, smoothest stops possible —increasing production, with no unusual wear.

Because DYNAC is completely electrical, it is simple to install. No costly fittings and troublesome mechanical apparatus. The compact, self-contained unit can be installed anywhere, at machine or for remote operation.

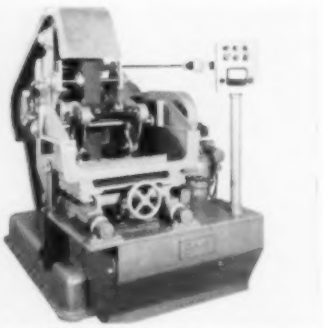
DYNAC is giving fast, smooth moneysaving stops on many applications throughout industry. Call your Westinghouse representative or distributor. Or, write Westinghouse Electric Corporation, 3 Gateway Center, Pittsburgh 30, Pennsylvania.

J-22000

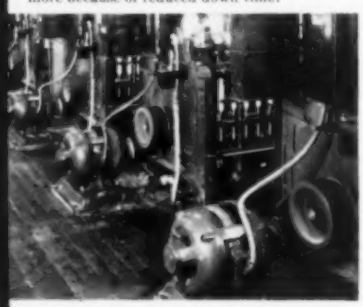
YOU CAN BE SURE...IF IT'S

Westinghouse

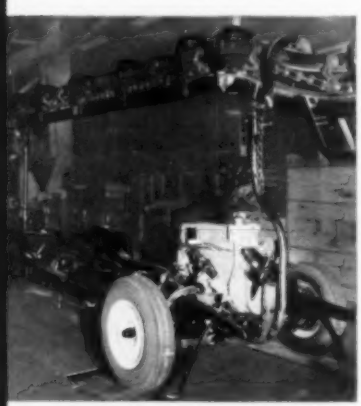
HERE ARE SOME TYPICAL APPLICATIONS:



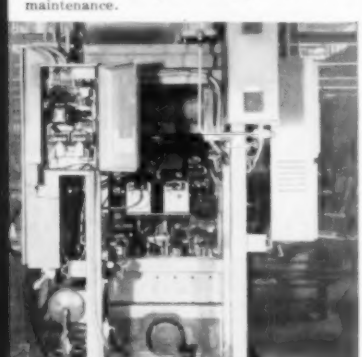
GRINDING MACHINES with DYNAC produce more because of reduced down time.



SPINNING FRAMES with DYNAC have saved owners over $3,000 per year per 100 frames.



CONVEYORS using DYNAC can be stopped once a minute, day in and day out, with no maintenance.



AUTOMATIC WELDERS with DYNAC can complete 600 operations per hour—20 stops per minute—24 hours a day.

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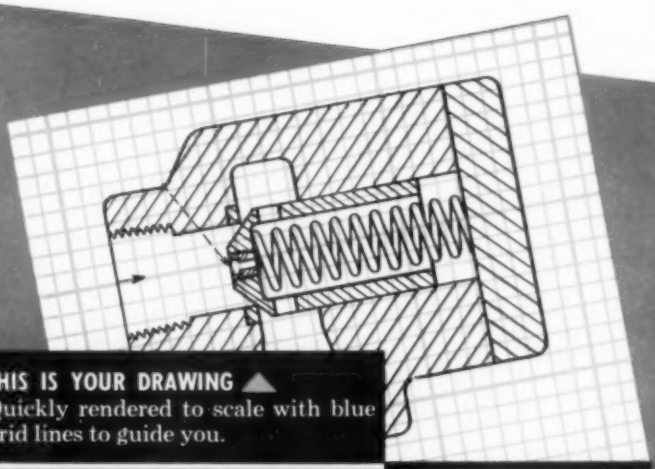

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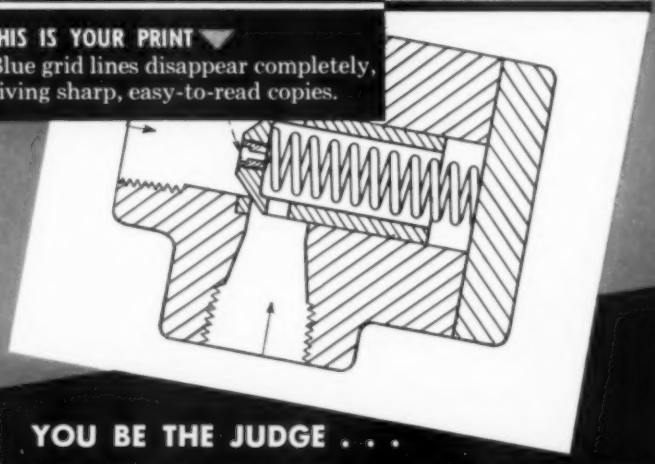

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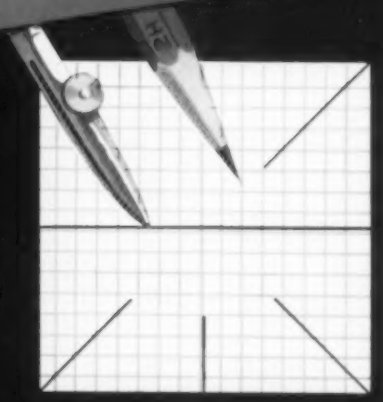

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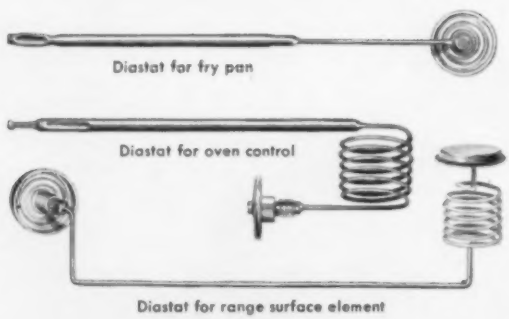
DIASTAT
Sensing Elements



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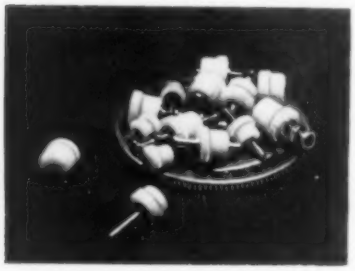
For designers seeking savings, Bridgeport Diastats permit elimination of ambient temperature compensating devices. The large ratio of bulb volume to diaphragm volume makes such costly extras unnecessary.

For designers improving appliance performance, Bridgeport Diastats offer permanent accuracy with no drift. Calibration is consistent; resetting is never needed. These superior operating characteristics are assured for the life of the appliance.

Bridgeport Diastat Sensing Elements are particularly suited to applications using a very short stroke, and for temperature ranges up to 650° F.

Robertshaw-Fulton
CONTROLS COMPANY

BRIDGEPORT THERMOSTAT DIVISION
Milford • Connecticut



ment, without need of nuts, washers, or lockwashers. Having a Teflon body, these terminals resist breakage, are shock-resistant and resist humidity, corrosion and fungus. Scalectro Corp., 610 Fayette Ave., Mamaroneck, N. Y.

For more information—
Circle 55, inside back cover

Angular Divider

This unit is said to position a synchro shaft with less than 15 sec error. It will rotate the synchro in 5° steps through use of ball-detent mechanism. The interval between is spanned by a fine-angle device. This divider, 12 in. dia x 5¾ in. high, will accommodate synchros size 8 to 31. Theta Instrument Corp., 204 Market St., E. Paterson, N. J.

For more information—
Circle 56, inside back cover

Thermal Time Delay Relay

Designed for high performance and long life, this unit may be used in applications including circuits to provide definite on-off time intervals to delay the application of high voltage until after warm-up period. They have single-pole, double throw contact action, high ambient temperature range and freedom from chatter and arcing. Factory pre-set, time delays on metal are from 3 to 120 sec, with glass 5 to 60 sec. Available in metal envelope,

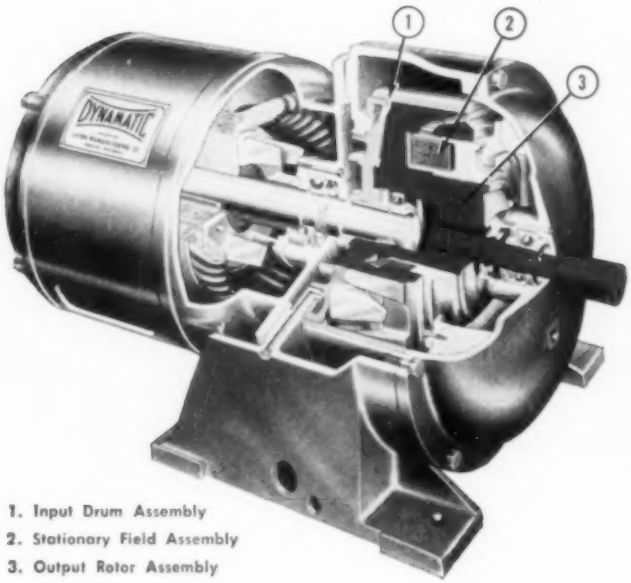
(Continued on page 250)

EATON

DYNAMATIC®

DYNASPEDE® ADJUSTABLE SPEED DRIVES

Provide these important Advantages



1. Input Drum Assembly
2. Stationary Field Assembly
3. Output Rotor Assembly

1. Adjustable speed from AC power source
2. Accurate speed control
3. Wide speed range
4. Rapid response
5. Low power losses
6. No commutators, rings, brushes, or rotating coils
7. Simple construction
8. Remote control
9. Quiet, efficient operation
10. Low maintenance cost

For a long list of industrial drive applications where stepless adjustable speed is required, the new Dynamatic Dynaspede® Drives are ideal. The liquid-cooled, completely enclosed, stationary field eddy-current couplings are available mounted integrally with D-flange squirrel cage motors in capacities from 3 to 75 HP. Motor types available are drip-proof, totally enclosed fan-cooled, and explosion-proof.

Separately mounted couplings in capacities from 3 to 2500 HP, and larger, are also available. Dynamatic electronic or magnetic amplifier controls, in combination with these drives, provide wide latitude in operating functions.

Send for Illustrated Literature Describing These New Stationary Field Drives and Couplings

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MANUFACTURING COMPANY
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SAW TOOTH*WASHERS

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FLAT WASHERS — Meets new ASA and SAE standards . . . steel, brass, bronze, monel, aluminum, and stainless steel . . . any finish.

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Company _____
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miniature (7 and 9 pin or octal (8 pin), and in a glass envelope in 9-pin only. Curtiss-Wright Corp., Wood-Ridge, N. J.

For more information—
Circle 57, inside back cover

Miniature Pull-Type Solenoid

A miniature pull-type solenoid for aircraft, missile and electronic applications that operates with high efficiency and extremely low plunger friction loss has an operating temperature range of −65 F to 100 F.

Operating voltage is from 6 to 100 v d-c with plunger operating under side force of 8 to 10 g. At 0.3 amp, 100 v d-c and 78 F, force is 1.3 lb with stroke 0.03 in. Under these same conditions, force is 0.8 lb with stroke 0.06 in. and 0.4 lb with stroke 0.125 in. Carruthers & Fernandez Inc., 1501 Colorado Ave., Santa Monica, Calif.

For more information—
Circle 58, inside back cover

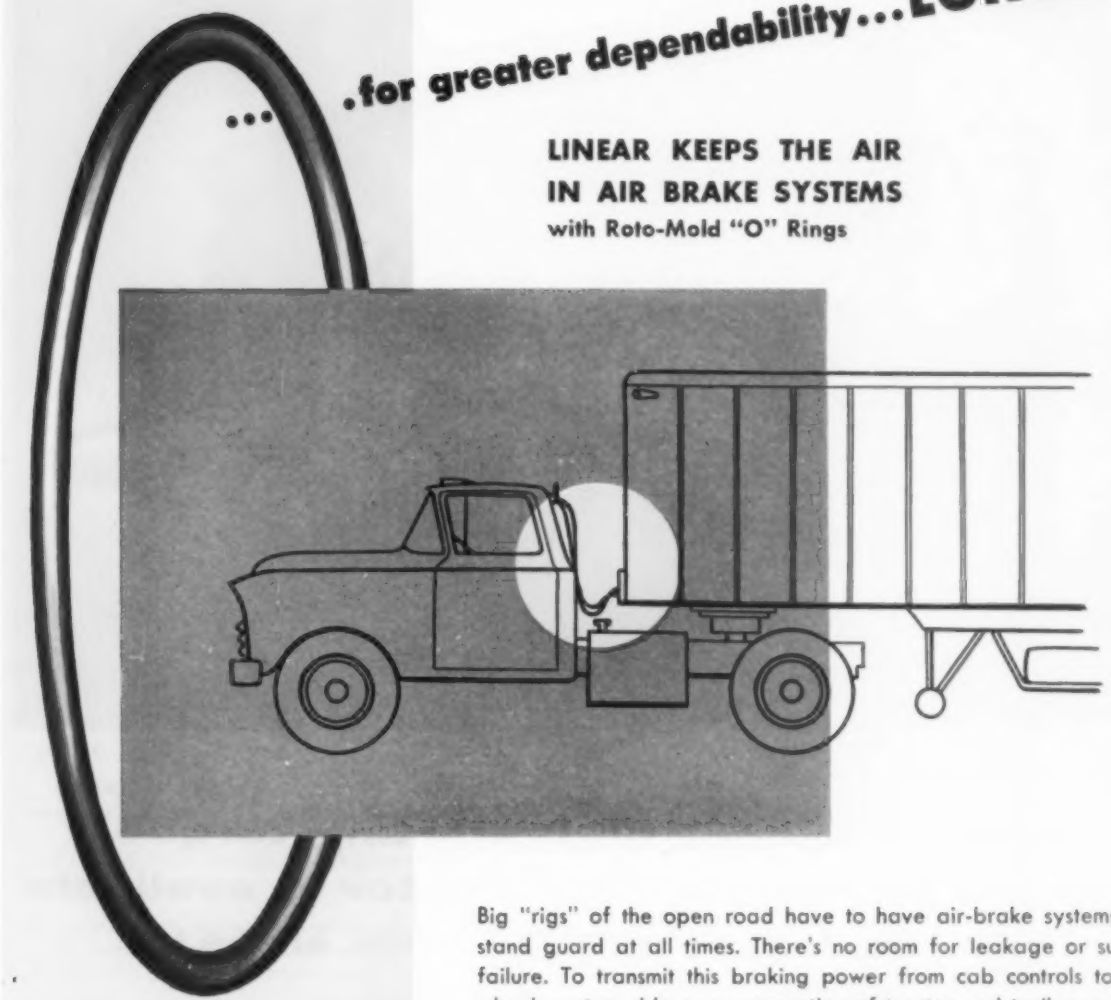
Silicon Rectifier

Ratings up to 140 amp per cell are available in a high power silicon component rectifier. Suitable applications

(Continued on page 254)

. . . for greater dependability . . . LONGER

LINEAR KEEPS THE AIR IN AIR BRAKE SYSTEMS
with Roto-Mold "O" Rings



Big "rigs" of the open road have to have air-brake systems that stand guard at all times. There's no room for leakage or sudden failure. To transmit this braking power from cab controls to rear wheels, yet enable easy separation of tractor and trailer, requires flexible hoses with quick disconnects. These coupling devices must have a positive seal, withstand braking pressure and mechanical abuse, yet connect or disconnect with ease.

LINEAR'S ability to produce precision "O" rings—fast and economically—has provided safe, positive seals for airhose couplings . . . to keep the air in air brake systems. The exclusive Roto-Mold process assures physically better seals . . . dimensionally stable . . . free from foreign inclusions and flash.

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LINEAR
LINEAR, Inc., STATE ROAD & LEVICK ST., PHILA. 35, PA.

Wagner Type RA Single-phase Motor
Repulsion-start Induction 1 through 5 hp.

NOW...Wagner's high starting torque Integral hp single-phase motor is available in the latest NEMA frame sizes!

The well-known Wagner Type RA Motor is the workhorse of the single-phase motor field. This repulsion-start, induction-run motor combines the best features of the repulsion motor in starting, with those of the induction motor while running at rated operating speeds—ideal for applications requiring high starting torque.

No other single-phase motor has its ability to continually start heavy loads or perform with such complete satisfaction under continuous service.

Specifically designed for compressors, pumps, machine tools, grinders, and conveyors; it is preferred for many other single-phase high inertia or heavy friction starting applications because of its ability to start such loads with low current and with minimum light flicker.

Let a Wagner field engineer show you how these motors can be applied to your needs. Call the nearest of our branch offices, or write us.

OLD FRAME SIZE	NEW FRAME SIZE
203	182
204	184
224	213
225	215
254	254U

4 pole (1750 RPM, 60 cycle and 1450 RPM, 50 cycle) ratings are interchangeable in mounting dimensions with capacitor-start motors of the same ratings.

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6406 Plymouth Ave., St. Louis 14, Mo., U.S.A.

M57-11

ELECTRIC MOTORS • TRANSFORMERS • INDUSTRIAL BRAKES • AUTOMOTIVE BRAKE SYSTEMS—AIR AND HYDRAULIC

From the tick of a Wristwatch

to the roar of a Guided Missile

precision operation depends upon

Hunter Douglas Aluminum Cold Forgings!

A question frequently asked by designers is . . . "How small or how large a part can you economically cold forge?"

Out of thousands of Hunter Douglas production items, at one end of the scale is the tiny wristwatch bezel case. Weighing only a hundredth part of a pound, it is cold forged from high purity aluminum, complete with band attachment lugs. Wear properties are superior to gold and gold anodizing imparts a beautiful and lasting finish.

Typical of the largest pieces cold forged to date are aluminum alloy motor tubes. Hunter Douglas supplies these as prime contractors to the U. S. Navy for use in the SIDEWINDER missiles, as well as for the new "ZUNI" rocket. Some rocket tubes measure over 6 feet in length.

SO MUCH FOR SIZE, BUT HOW ABOUT ACCURACY? The watch case speaks for itself, but tolerances of the rocket motor tubes are even more exceptional for their size . . . straightness to .020" TIR, I.D.'s to ±.006" and uniformity of wall thickness to ±.0015". Other tubes are produced with walls as thin as .015", some as thick as .250" or more. *Typical concentricity of these is within .001" with wall tolerances of .002" and straightness in the range of .005"/ft.—in any alloy!*

Between these size extremes lies a vast number of hollow components which can be economically cold forged—with almost complete elimination of, or greatly reduced, machining costs. If you require parts having *superior strength, zero draft, smooth finishes* and *mechanical properties comparable to hot forgings* you'll find an answer in Hunter Douglas Cold Forgings . . . now available in *high strength aluminum alloys, and experimentally in oxygen-free copper, zirconium, magnesium and many steels!* Ask us for recommendations.

Hunter Douglas Aluminum

Division of
BRIDGEPORT BRASS COMPANY
Dept. PE-7, Riverside, California, Telephone OVerland 3-3030

YOUR PRODUCTION

FUTURE

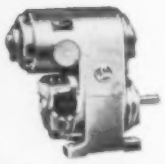
IS BUILT INTO...

...STERLING SPEED-TROL VARIABLE SPEED MOTORS

Sterling Speed-Trol Variable Speed Motors are fundamental to the success of any manufacturing operation involving changing production conditions. Speed-Trols give machinery the versatility which assures optimum productivity regardless of manufacturing variables. They also prevent obsolescence of machinery due to changes in processes or production volume. As insurance against future or unanticipated changes, it will pay you to investigate Sterling Speed-Trol Variable Speed Motors. They have your production future built into them.

Write today for Bulletin No. 188. Discover the big advantages Sterling Speed-Trol Variable Speed Motors can bring to your plant.

Sterling offers you a wide range of Electric Power Drives of advanced design—variable speed or constant speed—with manual or automatic controls.



STERLING SPEED-TROL VARIABLE SPEED MOTORS

STERLING SLO-SPEED GEAR MOTORS

STERLING CONSTANT NORMAL SPEED MOTORS

STERLING MULTI-MOUNT SPEED REDUCERS

STERLING ELECTRIC MOTORS

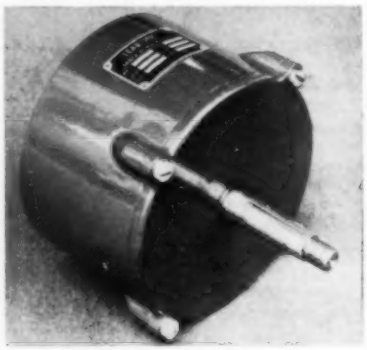
Los Angeles 22 • Chicago 35 • Cincinnati 37 • New York 51

Sm

are d-c power supplies, electrolytic-electrochemical equipment, battery chargers, computers, radar, tube filament power supplies and similar electrical apparatus. Heart of the new rectifier is a small silicon wafer in a hermetically sealed enclosure of ceramic and welded stainless steel.

These rectifiers are designed for air or liquid cooling and may also be used in convection-cooled applications at lower current ratings. General Electric Co., Schenectady 5, N. Y.

For more information—
Circle 59, inside back cover



Permanent Magnet Alternators

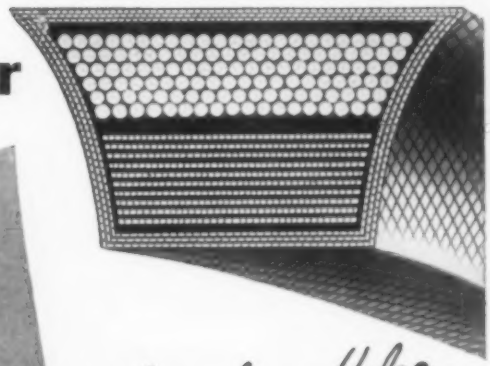
A new type of permanent magnet alternators may find use in aircraft, guided missile, automotive, and industrial applications. A new principle of rotor construction permits these brushless generators to be driven by electric motors, jet air drivers, turbines, and two- and four-cycle gasoline engines. Rotor can withstand-acceleration and overspeed condition for extended periods of operation.

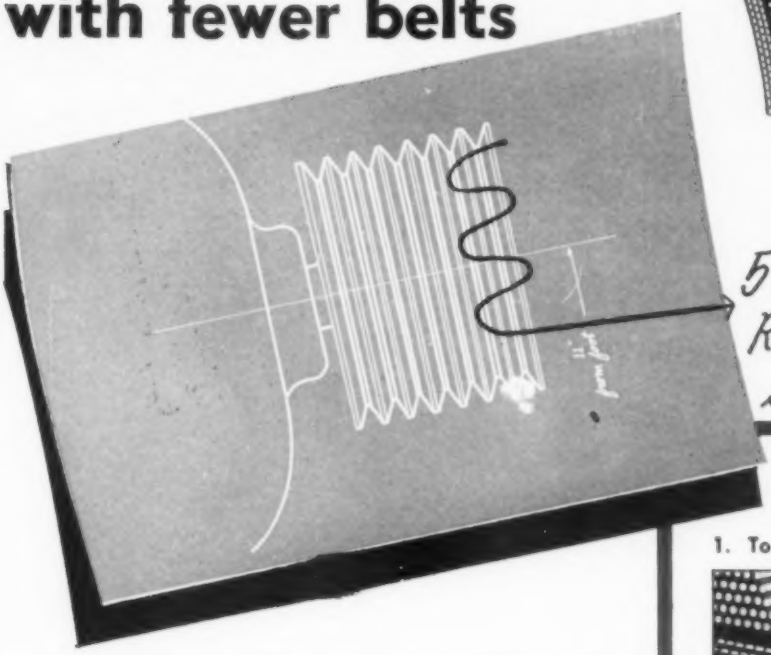
Since these alternators employ per-

(Continued on page 256)

Cut sheave width and weight...

get same horsepower with fewer belts





5 Gates Super Vulco Ropes do the work of 7 standard V-belts

Where space is limited and weight a factor, design your drive with this important fact in mind:

5 Gates Super Vulco Ropes do the work of 7 standard V-belts

That's because a Gates Super Vulco Rope has 40% more horsepower capacity — delivers more horsepower per dollar invested than any standard V-belt drive. Sheaves with fewer grooves cost less . . . weigh less . . . take less room. Drive design is invariably improved.

A wealth of drive data is quickly available to you. Simply call your nearby Gates distributor for a Gates V-belt specialist. Stocks carried in industrial centers around the world.

The Gates Rubber Company
Denver, Colorado

GATES Distributors are in the Yellow Pages

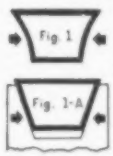
The Mark of Gates *Specialized* Research

No other V-Belt has ALL these advantages

1. Tough, resilient Tensile Cords

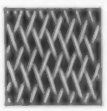
Super strong resilient tensile cords provide 40% greater horsepower capacity . . . easily absorb heavy shock loads . . . reduce number of belts required . . . save weight and space.

2. Concave Sidewalls (U.S. Pat. 1813698)



Concave sides (Fig. 1) increase belt life. As belt bends, concave sidewalls become straight, making uniform contact with sheave groove (Fig. 1-A). Uniform contact means less wear on sides of belt . . . far longer belt life.

3. Flex-Weave Cover (U.S. Pat. 2519590)



A Gates exclusive: provides greater flexibility with far less stress on fabric. Cover wears longer . . . increases belt life . . . more power available to driven machine.

4. High Electrical Conductivity

Built into Gates Super Vulco Ropes for safer drives (in explosive atmospheres).

5. Oil, Heat, Weather Resistant

Special rubber compounds make Super Vulco Ropes highly resistant to heat, oil, and prolonged exposure to weather.

TPA 248

Gates Super VULCO ROPE Drives

REDUCE YOUR COSTS!

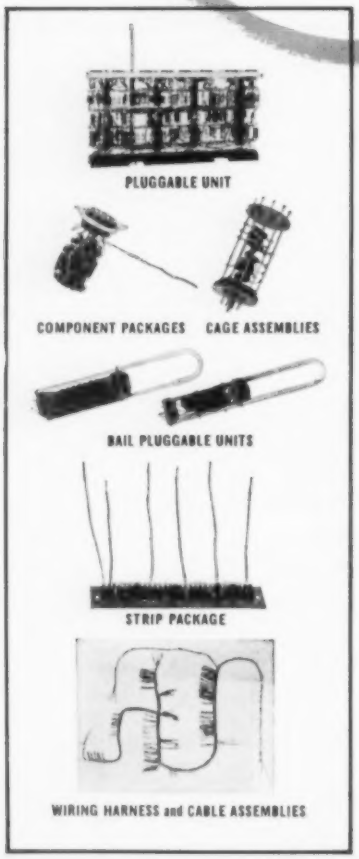
LET

ERIE

PRODUCE YOUR

Electro-Mechanical

PACKAGED ASSEMBLIES



• **SAVE COSTS . . .**

Industrial Engineering experts, having the depth of experience from many similar jobs, can apply tried methods to gain the lowest possible production cost.

• **INTEGRATED FACILITIES . . .**

Ready access is available to other ERIE divisions for electronic components, molded plastic parts, metal stampings, embossed wiring boards.

• **TRAINED PRODUCTION PERSONNEL . . .**

Trained production personnel is available immediately without the burden of training costs.

• **WELCOME CONSULTATION . . .**

Contact ERIE representative for possible economies to be gained through use of our facilities.

Write for complete information about our facilities and Engineering Bulletin 453 describing typical ERIE assemblies.

ERIE electro-mechanical

ERIE ELECTRO-MECHANICAL DIVISION
ERIE RESISTOR CORPORATION
Main Offices: ERIE, PA.
Factories: ERIE, PA. • HAWTHORNE, CALIF.

manent magnetic fields, they require not external excitations and no slip rings, commutators, or brushes. Sparking, explosion hazards, radio interferences, and maintenance are virtually eliminated.

Offered for most standard voltages, 400 cps, single-phase; or three-phase, either Y or delta-connected. Other available configurations include compound units, delivery both a-c and d-c with built-in forced air-cooled rectifiers; two-bearing type units for belt or direct coupling drive, or for direct outboard mounting on driving motor or engine; units with standard AN pads for hydraulic motor drives. Output ratings range from 500 to 4500 va. Lear Inc., 3171 S. Bundy, Santa Monica, Calif.

For more information—
Circle 60, inside back cover

Potentiometer

This ¾ x ¾ in. long, 2 w precision wirewound potentiometer uses a one piece anodized aluminum housing to obtain a low loss phenolic terminal board, and winding assembly. Shaft torque is 0.05 in.-oz; 0.02 in.-oz available on special request. Resistance

values from 25 ohm to 50 kw. Maurey Instrument Corp., 7924 S. Exchange Ave., Chicago 17, Ill.

For more information—
Circle 61, inside back cover

Lightweight Power Supply

Unit delivers 400 cps, three-phase, 120/208 v, 15 kva continuous, 22.5 kva for short period overloads. Totally enclosed, fan-cooled construction is used. The use of light metals holds weight within 500 lb. for complete motor-generator combination. Overall dimensions 36 x 19 x 21 in. Elimi-

(Continued on page 260)

We hate to admit it but we had trouble with a

Bellows Air Motor

in Reading, Pennsylvania

Bellows Air Motors — the unique air cylinder with the built in valve — have established enviable records for trouble free performance. Operating cycles of 20,000,000 to 30,000,000 without maintenance of any kind are quite common. Fifty million cycles nothing unusual.

But trouble sometimes occurs — even in the best regulated families. A few weeks ago we received a phone call late at night. A Bellows Air Motor on an important production line had gone haywire. Could we ship a replacement immediately? We did better than that. We had a Bellows Field Engineer at his plant at 8:00 the next morning. At 9:00 the line was back in operation.

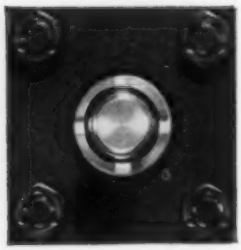
More than 125 Bellows Field Engineers (one or more in every major industrial area in the United States and Canada) are your assurance that if you ever do have trouble with any Bellows equipment it will be remedied quickly with minimum down time. (But between us girls, trouble with Bellows "Controlled-Air-Power" Devices is most unusual!)

The Bellows Co.

AKRON 9, OHIO

MANUFACTURERS OF CONTROLLED-AIR-POWER DEVICES FOR FASTER, SAFER, BETTER AND **LOWER-COST** PRODUCTION

B30-B



Here are the world's finest power cylinders

...competitively priced!

This ad is written for the man who has thought all cylinders are "pretty much alike." That just isn't so, and your Hannifin man would like an opportunity to show you why...

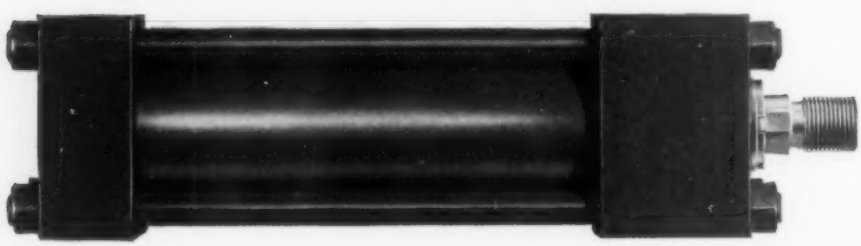
He'll show you design features that other cylinders simply do not have... extra quality workmanship at critical points that pays off in longer life ...accessibility that simplifies their infrequent maintenance. And when he talks price and delivery, you will find these better features cost you no more, can often be delivered sooner.

We think you'll agree that it pays to standardize on Hannifin cylinders.

AIR AND HYDRAULIC

HANNIFIN

POWER CYLINDERS



COMPLETE CYLINDER FILE

Write for your copy of this new Hannifin Cylinder File . . . complete, easy-to-use, easy-to-order-from information on five lines of Hannifin Cylinders. Write Hannifin Corporation, 525 S. Wolf Road, Des Plaines, Ill.

J&L cold drawn ELECTRICWELD tubing with a superior SPECIAL SMOOTH I.D. finish

Cold drawn ELECTRICWELD tubing with the superior smooth I.D. finish will cut your production costs in applications like these:

- **cylinder tubing**
- **hydraulic and pressure tubing**
- **shock absorbers**
- **ordnance components**

This new drawn-over-mandrel grade tubing with its mirror-like surface finish helps reduce or eliminate costly machining on many applications. For example, it may be used, without inside honing, for many cylinders through which plungers are passed.

ELECTRICWELD tubing withstands high internal hydrostatic pressures; carries heavy torsion loads; resists high-frequency vibration. It offers a favorable weight-to-strength ratio where loading occurs in all directions.

It is furnished in OD sizes from ½ inch to 2⅞ inches and in wall thickness from 20 to 10 gauge, 0.035 and 0.134 inch. Send coupon today for complete information.

Jones & Laughlin Steel Corporation
Dept. 409, 3 Gateway Center
Pittsburgh 30, Pennsylvania

Send me a copy of your cold drawn ELECTRICWELD tubing booklet.

Name_____

Title_____

Company_____

Address_____

City_____ Zone___ State_____

J&L STEEL

Jones & Laughlin

. . . a great name in steel

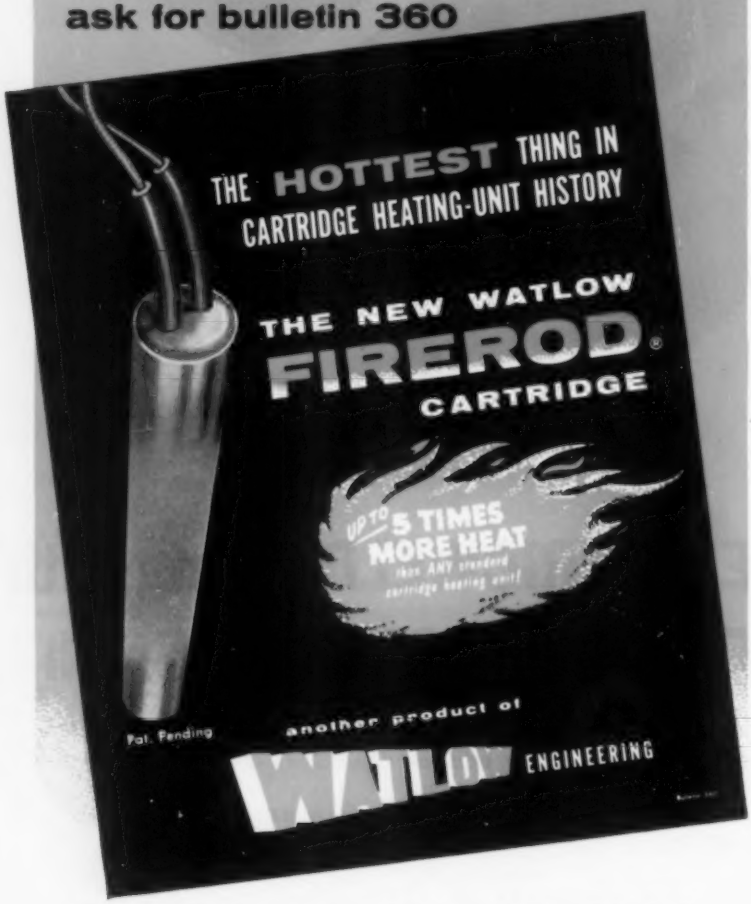
Learn all about the NEW

FIREROD®

CARTRIDGE HEATING UNIT

Write for your FREE copy!

ask for bulletin 360



WHERE it can fit into *your* design needs that call for high heat concentration in a small amount of space.

WHAT actual tests prove about the FIREROD'S superiority in high temperature potential and long operating life.

HOW to determine watts densities, temperature control points for your installation.

ALSO charts, tables, illustrated units.

WATLOW

SINCE 1922—DESIGNERS AND MANUFACTURERS OF ELECTRIC HEATING UNITS

ELECTRIC MFG. CO.
1392 FERGUSON AVE.
SAINT LOUIS 14, MO.

nation of brushes is said to reduce maintenance to infrequent lubrication of bearings.

Motor operates at low speed of 1800 rpm, from standard 220/440 v, three-phase, 60 cps supply. Georator Corp., Manassas, Va.

For more information—
Circle 62, inside back cover

Electro-Magnetic Clutches and Brakes

The assembly provides complete release when the clutch or brake is de-energized and zero backlash when it is energized. The pole shoe permits the units to handle considerable misalignment up to 3° angular, without binding or loss of power. Series 100 units measure ⅛ in. dia. x 2 in. long and deliver torque in excess of 3 in. lbs. Series 130 units measure 1⅛ in. dia. x 2¾ in. long and deliver 7 in.-lb of torque. Maximum power consumption is 3 w. Dial Products Co., 9 Ave., E. Bayonne, N. J.

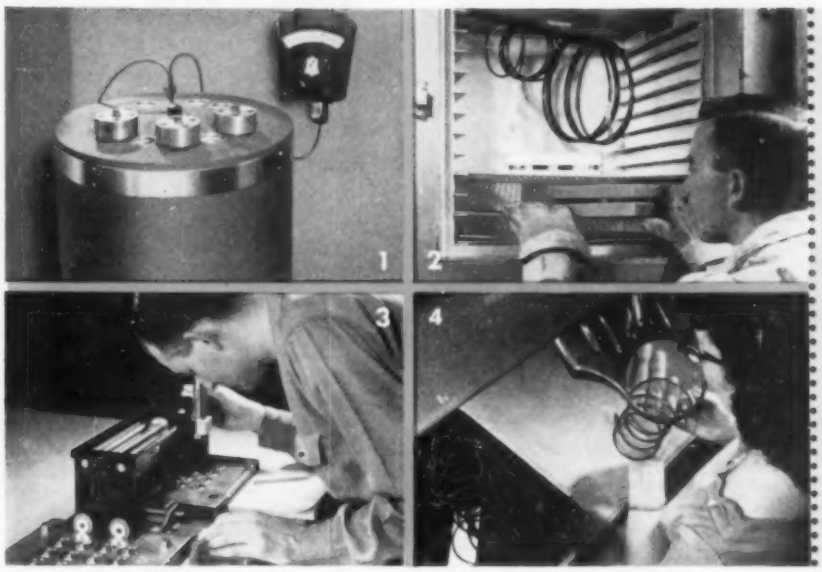
For more information—
Circle 63, inside back cover

Tilting Motor Base

A tilting motor base compensates for belt tension when speed changes are made while the machine is run-

(Continued on page 262)

Precision certified specification "O" rings from compound 830-70...quality proved by all ASTM Tests



These controls, some of which are used exclusively at Precision, assure quality.

1 A Precision modification of this Aluminum Block Ager provides "O" ring tests up to 600° F. in many volatile fluids.

2 "O" rings are accurately checked for compression and high temperature resistance in this efficient oven.

3 This Precision developed Inspection Stage controls "O" ring molding to exacting tolerances.

4 Rigid inspection under shadow-free illumination assures highest quality.

Modern pretesting methods and engineering skill have made Precision "O" ring Compound 830-70 a leader in its field. This compression molded "O" ring far exceeds the requirements of SAE 120R Class 1 for oil resistant service. Under ASTM testing procedure, compression set readings average ½ the specification requirements.

"O" ring Fatigue Test disclosed 830-70 to be over 100% better than specification. Tests at 300F in ASTM oil No. 1 and No. 3 showed equally remarkable superiority.

If you are a manufacturer of automotive, machine tool, farm transportation and similar equipment, Precision Compound 830-70 may be your answer to positive long life sealing and trouble-free maintenance... For finest quality—for engineering and product design service you can rely on Precision.

Write for your free copies of Precision catalogs on "O" Rings and Dyna-seals

Precision Rubber Products Corporation

"O" Ring and Dyna-seal Specialists

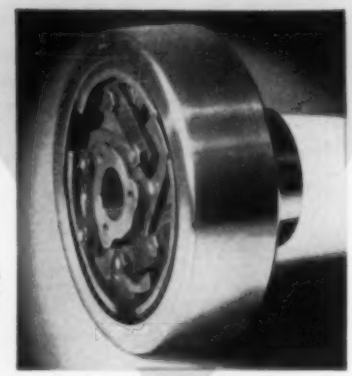
Dept. 3, Oakridge Drive, Dayton 7, Ohio Canadian plant at: Ste. Thérèse de Blainville, Québec

CLUTCHES FOR POWER CONTROL DESIGNS

THE NEW HILLIARD-TWIFLEX
Centrifugal Coupling

1
AUTOMATIC
smooth starting with protection against overload shock.

2
FLEXIBLE
in all directions without any loose joints.



3
ADJUSTABLE
to exactly suit the operating conditions.

4
SIMPLE CONSTRUCTION
and easy assembly even in blind installations.

HILLIARD-TWIFLEX Centrifugal Couplings provide automatic shockless power transmission and trouble-free operation even under relatively great misalignment without any lubrication whatsoever.

They are being used very successfully in the drive of compressors—agricultural sprayers—mixers—conveyors—generators—fans and blowers—pumps—hammer mills—crushers—winches and hoists—refrigeration equipment—textile machinery—and wherever smooth, efficient operation is needed.

Tests in a variety of installations for over five years prove the Twiflex is the practical solution to many drive problems.

WRITE TODAY FOR BULLETIN CE-3 WITH COMPLETE INFORMATION.

★ CONSIDER AUTOMATION-INVESTIGATE THESE PRODUCTS

• OTHER HILLIARD CLUTCHES •

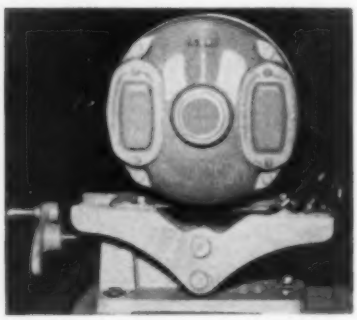
SINGLE REVOLUTION CLUTCHES for automatic accurate control—electrical or mechanical—or intermittent motion, indexing, cycling and cut-off. Ask for Bulletin 239.

OVER-RUNNING CLUTCHES for automatic instantaneous engagement and release on two speed drives, dual drives and ratchet or backstop action. Ask for Bulletin 231.

SLIP CLUTCHES for overload protection, or constant torque and to provide constant tension and permit speed variation on rewind stands. Ask for Bulletin 300.

THE HILLIARD Corporation
MANUFACTURING CLUTCHES FOR OVER 50 YEARS
101 W. FOURTH ST ELMIRA, NEW YORK

IN CANADA: UPTON • BRADEEN • JAMES, LTD.



ning. The unit features one size base for all fhp motors. Because of its tilting movement it requires minimum space for adjustment. Actual base size is 5½ x 7½ in. Correct belt tension and alignment are constantly maintained by a hand-wheel screw adjustment which changes the angle of tilt. Lovejoy Flexible Coupling Co., 4856 W. Lake St., Chicago 44, Ill.

For more information—
Circle 64, inside back cover

Thermal Switch

A precision temperature controller providing several operating ranges from −100 F to 1100 F, are furnished in a-c and d-c with differential at set-

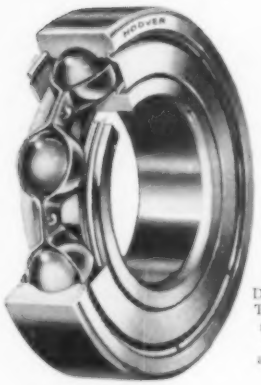
ting point of ±2%. Switches can provide differential as close as 1 F. Scaico Controls Inc., Cooper St., Delanco, N. J.

For more information—
Circle 65, inside back cover

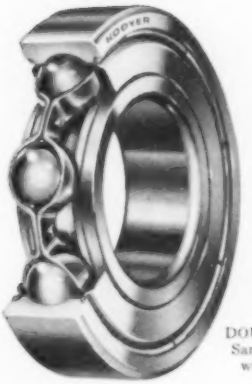
Parallel Shaft Gearmotors

Units with integrally mounted gear heads and motors provide speed without the cost and maintenance of additional transmission equipment. Permanent alignment is built-in, for extended gear life, and maximum pro-

(Continued on page 266)



DOUBLE SEAL—
Teflon contact seal shown. Available with snap ring and with single or double seal.

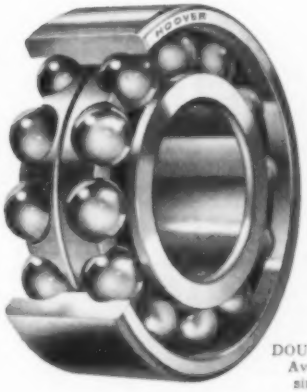


DOUBLE SHIELD—
Same sizes available with single shield.

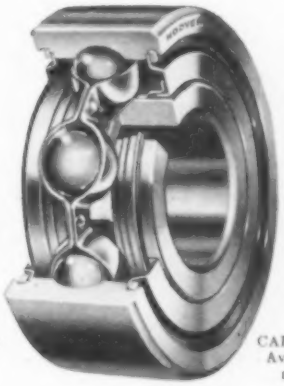
SINGLE ROW RADIAL—
Also available with snap ring.

when you want quality

COMBINATION FELT SEAL AND SHIELD—
Either standard or wide outer ring.



DOUBLE ROW—
Available with single shield.



CARTRIDGE—
Available with snap ring.

you want hoover

When you want *quality* bearings to add to the performance, long life and smooth operation of your products, you want Hoover Ball Bearings.

Hoover Ball Bearings combine the exactness of *Micro-Velvet* Lapped Balls with the smoothness of *Hoover Honed* Raceways. The result . . . top quality bearings that assure unexcelled performance—quietness—long life—and heavy load capacity.

Investigate Hoover's line of ball bearings in the light, medium and heavy series. Their microscopic precision adds up to your best buy in ball bearings. Manufacturers are invited to call in Hoover engineers for technical assistance. Write for information.

Micro-Velvet and *Hoover Honed* are Hoover Trademarks.

HOOVER BALL AND BEARING COMPANY, ANN ARBOR, MICHIGAN

Send information about

- ☐ Single Row Radial Bearings
- ☐ Bearings with Shields
- ☐ Bearings with Seals
- ☐ Combination Shield and Seal
- ☐ Cartridge Bearings
- ☐ Double Row Bearings

Hoover Ball and Bearing Company, Ann Arbor, Mich.

Please send information checked. Mail copy of "Hoover Handi-Book of Anti-Friction Bearings."

Name_____

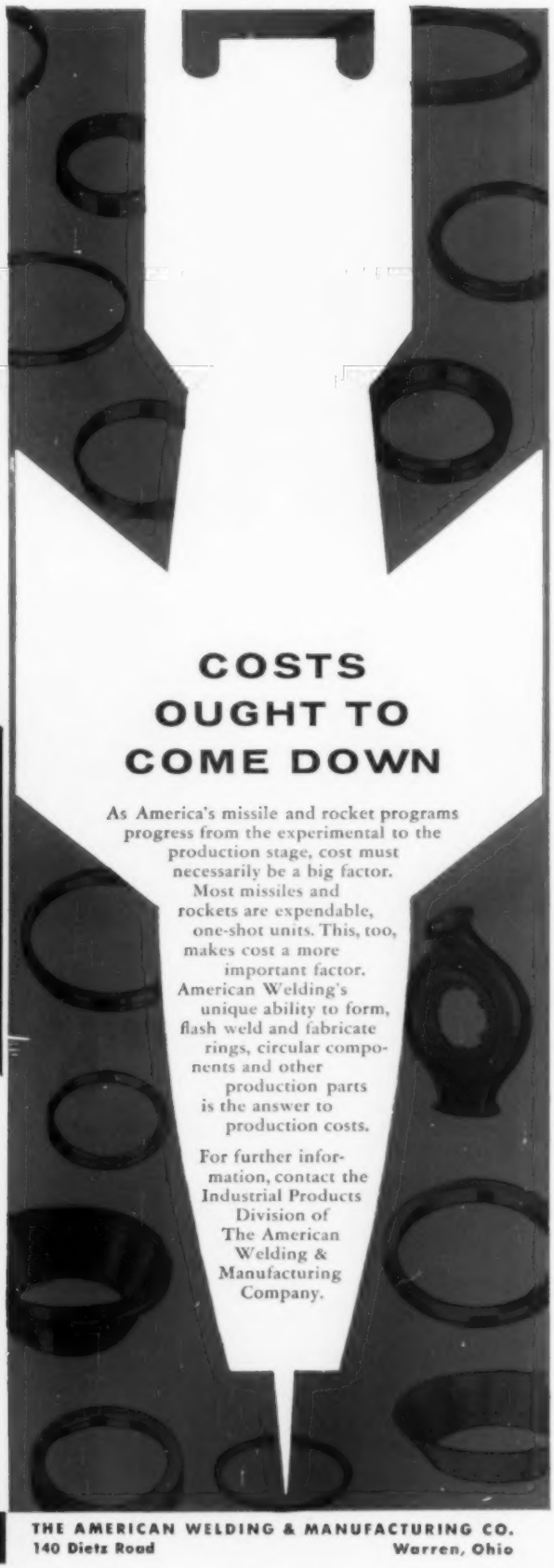
Title_____

Company_____

Address_____

City_____ State_____

PE10



COSTS OUGHT TO COME DOWN

As America's missile and rocket programs progress from the experimental to the production stage, cost must necessarily be a big factor. Most missiles and rockets are expendable, one-shot units. This, too, makes cost a more important factor. American Welding's unique ability to form, flash weld and fabricate rings, circular components and other production parts is the answer to production costs.

For further information, contact the Industrial Products Division of The American Welding & Manufacturing Company.

THE AMERICAN WELDING & MANUFACTURING CO.
140 Dietz Road **Warren, Ohio**

from Ciba Research . . .

2 important NEW EPOXY DEVELOPMENTS bring greater range and versatility than ever to formulating design.

ARALDITE® 6005

is the newest addition to CIBA's family of basic epoxy resins—already the widest range available. Characteristics and special features of Araldite 6005 are shown below.

ARALDITE RD-1

is CIBA's Butyl Glycidyl Ether, and is your means of adapting the viscosities of Araldite Epoxies to fit special needs. (RD means "Reactive Diluent".) Typical features are shown below.

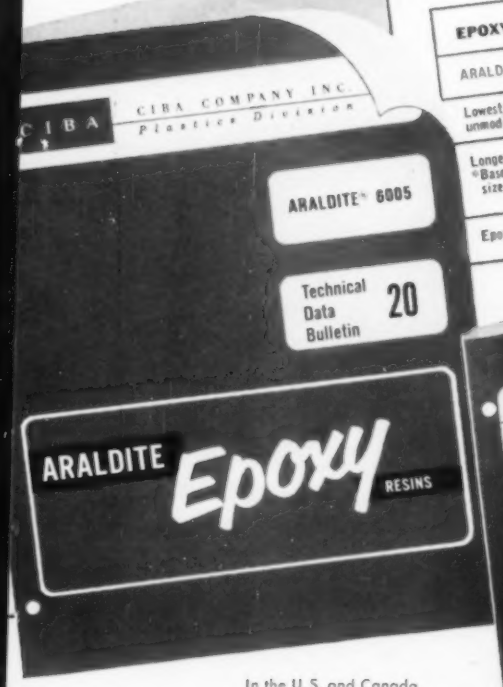
EPOXY RESIN	Characteristics
ARALDITE 6005	
Lowest viscosity unmodified resin	13,000 cps @ 75°F.
Longer pot life* *Based on equivalent batch size and hardener ratio.	From 20% to 70% longer pot life
Epoxy value, Eq./100g.	0.525

REACTIVE DILUENT	Typical Properties
ARALDITE RD-1	
Viscosity, centipoises at 75°F.	3
Specific Gravity	0.908
Epoxy value Eq./100g.	0.7

DILUTED RESIN CHARACTERISTICS	
ARALDITE RD-1 + ARALDITE 6005	Viscosity
0 phr.*	13,000 (control)
10 phr.	1,200
20 phr.	200

*parts Araldite RD-1 per hundred parts of Araldite 6005

Illustrated are CIBA's new Technical Bulletins No. 20 and No. 21 on Araldite 6005 and Araldite RD-1. Send in the coupon below for your copies. Sample also available on request.



In the U.S. and Canada CIBA produces basic resins only.

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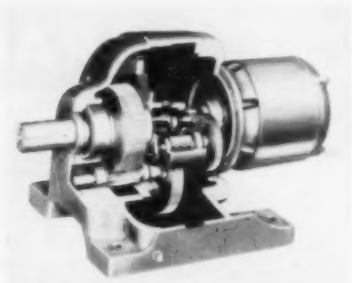
"Pioneers in Investment Casting"

Plants: Brooklyn, N. Y., Groton, Conn., Tilton, N. H., Los Angeles, Calif.

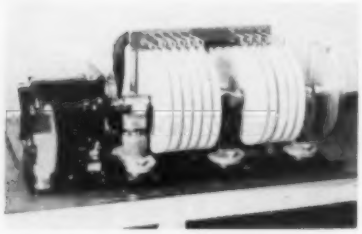
tection against oil leakage is achieved through double seals on honed surfaces on the high speed shafts and service-proved seals on output shafts. Helical gears are meshed to provide longer gear life and quiet operation.

Splash lubrication of all moving gear head parts minimizes wear and aids in the transfer of destructive heat. Motor bearings are of double-shield, permanently lubricated design. All motor housings and the smaller gear cases are cast of heat-treated alloy of aluminum which cuts weight and gives



higher tensile strength and faster heat transfer. Electra Motors Inc., 1110 N. Lemon St., Anaheim, Calif.

For more information—
Circle 66, inside back cover



Multi-Circuit Sequence Unit

A ten-circuit sequence programmer, with 6 in. dia adjustable nylon cams, provides the automatic testing device for capacitors and other electrical apparatus requiring production inspection. The timer includes a selector switch for flexibility of operation from either 115 v or 230 v. A complete cycle is generated by the cam shaft in 6 seconds and settings of the cams may be quickly changed by adjustment of lock-type bushings.

Switches are open bladed fine silver contacts rated for 15 amp. Gear trains are available with a variety of motors to accommodate a broad range of timing cycles from a few seconds to

(Continued on page 268)

Plan your gear buying with "the book"

You'll be days... and dollars ahead

The Boston Gear Catalog No. 56 is "the book" in constant use by men who specify and buy gears and other transmission parts, — for good reasons. They know it lists over 2000 types and sizes of standardized stock gears. They know that Boston Gears are top-rated for precision and performance. And they know, also, they can get

PROMPT DELIVERY OFF-THE-SHELF — FROM LOCAL DISTRIBUTORS — AT FACTORY PRICES

Why pay more (and wait) for "specials" when you can get Boston Gears FROM STOCK, nearby, to meet any specification? Be cost-wise . . . STANDARDIZE. Get your copy of Catalog No. 56. You'll be days and *dollars* ahead on any transmission job. Boston Gear Works, 71 Hayward Street, Quincy 71, Massachusetts.

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For nearest Distributor LOOK UNDER "GEARS" in the 'Yellow Pages'

7124 STANDARDIZED TRANSMISSION PRODUCTS

Stock Gears • Sprockets and Chain • Speed Reducers • Bearings • Couplings

Check the response-to-the-touch. You can actually feel the difference!

That's why the Paragon Drafting Machine noticeably cuts end-of-the-day fatigue . . . saves costly man hours . . . helps raise working standards.

See how easily protractor control ring can be reached—no matter what position your hand is in. Another time saver. Touch that ring with your *little* finger and scales rotate freely. Release pressure and scales automatically lock to nearest 15° position. And intermediate angles are just as easily set!

Top day-to-day performance is guaranteed by unique "open center" design of arms which protects smooth-working factory-set band tension.

A good look at a Paragon and a touch on that control ring is worth 1,000 words! Try it before you buy *any* drafting machine—you can *feel* the difference.

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several days in duration. The design is flexible to allow replacement of electrical switches with direct-acting pneumatic poppet valves for program sequencing of pneumatically operated devices such as diaphragm valves, cylinders. Automatic Temperature Control Co., 5200 Pulaski Ave., Philadelphia 44, Pa.

For more information—
Circle 67, inside back cover

Voltmeter with Expanded Scales

These miniature a-c voltmeters have D'Arsonval-type movements. Accuracy on all meters is said to be held to ±5% of the expanded portion of the scale. Standard ranges are 90-120, 90-130 and 90-140 a-c. Other ranges with the lowest starting at 80 v a-c can also be supplied; minimum scale

span is 30 v a-c. Standard scales are linear with black markings on a white scale. International Instruments Inc., P.O. Box 2945, New Haven 15, Conn.

For more information—
Circle 68, inside back cover

Subminiature Relay

A subminiature relay occupying 0.18 cu in. of space features full ½ in. silver or palladium contacts. These handle 3 amp resistive load standard, and 4 amp intermittent. The basic design incorporates a permanent magnet in an electro-magnetic circuit of high efficiency and performance. This arrangement provides the extra armature torques necessary to overcome high contact pressures and actuate large contacts. Relay is constructed with a balanced armature having no pivots, hinges or bearings. Weight is 0.4 oz. Vibration resistance is 10 g to 2000 cps. The standard coil for 24v operation has 550-ohm

(Continued on page 272)

You're covered across the board

when you use

General Controls' line of quality automatic controls

In heating, power generation or process regulation – whenever automatic controls are needed – plant engineers everywhere have found that it pays to check *first* with General Controls. General Controls' comprehensive line ranges from the simplest time switch or thermostat to advanced programmers and recording controllers. And you're never very far from one of 40 helpful branches (located coast to coast), where General Controls' experienced representatives are always at your service. Give your local General Controls field representative a call on your next control problem.

K-21 MAGNETIC STOP VALVE

Packless – 2 way – normally closed. For air, gas, steam, water, oil, corrosive fluids. Pressures to 300 psi. Forged brass body. Stainless steel or soft seat.

K-27 MAGNETIC VALVE

Stainless steel for high sulphur fuels, syrups, juices, acids, alkalis, etc. Pressures to 300 psi. Midget size. Multi poised – operates in any position.

K-10 MAGNETIC VALVE

Lever action for higher seating pressure. Excellent general purpose valve for primary fuel, feed water, steam, air. (300 psi max. operating pressure differential.)

K-15 MAGNETIC VALVE

Piloted piston design. Large flow capacity with low pressure drop. For air, gas, steam, oil derivatives. Versatile – with 3 coil classes, 5 seat variations.

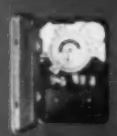
K-123 MAGNETIC VALVE

3 way – for normally open or normally closed directional control and mixer applications – on pneumatic or hydraulic operated devices, machine tools, etc.

K-273 MAGNETIC VALVE

3 way flow or mixer type. Compact, multi poised. For air, water, hydraulic fluids – charging or emptying systems. Normally open or closed. Choice of flow patterns.

TIME SWITCHES



Wide selection for domestic and commercial use – spring wound or motor driven, normally open or closed. For ventilating, lighting, refrigeration, etc.

HYDRAMOTORS

Wide range of types in complete range of pipe sizes and body styles to provide safe, dependable, durable answer to all liquid transfer problems.

AIR MOTOR VALVES

Air-operated diaphragm valve for modulating control. Normally open or closed, 3 way, or slide gates. Selection of various inner valves, body sizes and connections.

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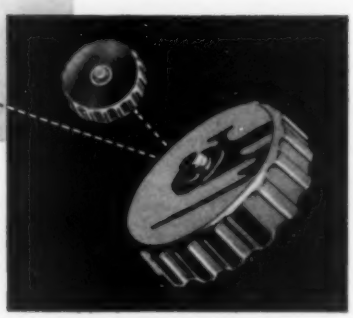
IMPORTANT COST REDUCTIONS

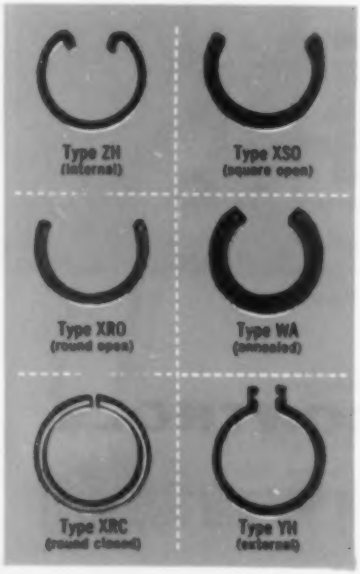
For Controls, Meters and Miniature Instruments

NATIONAL Retaining Rings conserve valuable space in portable equipment, pocket radios, hearing aids, controls, meters, instruments and miniature assemblies. Weight savings and reduction of manufacturing costs are added advantages.

Save time and materials ...and improve your products with...



NATIONAL RETAINING RINGS



Simplify design by specifying NATIONAL Retaining Rings on shafts and housings. These dependable rings save material, weight and assembly time wherever shoulders or collars are required. Grooving smaller diameters for retaining rings avoids cutting down larger diameter material to form shoulders and collars . . . saves costly machining, speeds assembly. NATIONAL Retaining Rings are service-proven on all types of equipment from heavy machinery to miniature assemblies. Ask for all the cost-saving facts, today!

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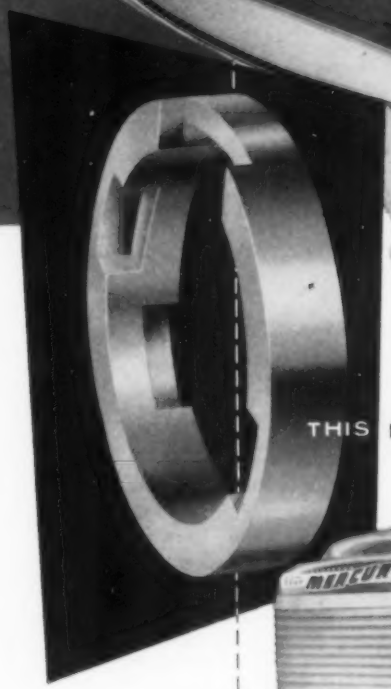
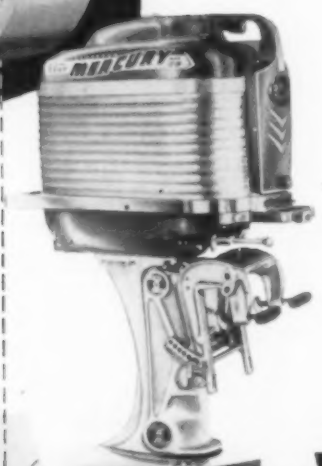
PRODUCED BY Keystone KIEKHAEFER

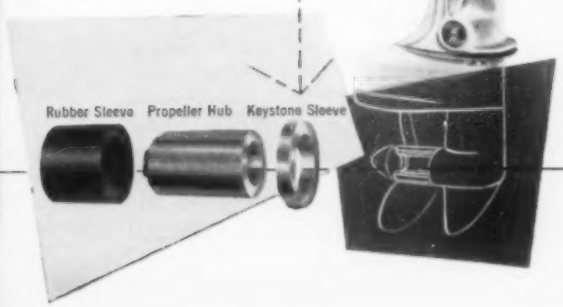
FOR MIGHTY MERCURY OUTBOARDS



THIS BRONZE POWDERED METAL SLEEVE
AVOIDS VIBRATION
IN CUSHIONED PROPELLER DRIVE



The rubber-cushioned flow of dynamic power to the Flo-torque propeller of four big Mercury engines is smoothed at the bearing point by a Keystone powdered metal part! Kiekhaefer Corporation molds this bronze insert integrally with the die-cast aluminum propeller housing. The sleeve assures positive alignment of propeller, eliminates development of vibration, and supplies built-in longevity. • Do *you* have a bearing problem? Bring it to Keystone—always at your service!



Keystone CARBON COMPANY

ST. MARYS, PA.

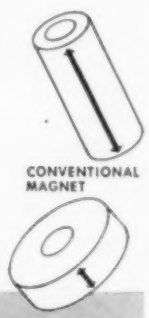
CERAMIC MAGNETS
bring you these design and engineering advantages...

- **GREATEST RESISTANCE TO DEMAGNETIZATION** of any commercial magnetic material.
- **ALL ENERGY FULLY USABLE** . . . without keepers, pole pieces or auxiliary air gaps.
- **CAN BE MAGNETIZED BEFORE OR AFTER ASSEMBLY.**
- **ALMOST INFINITE ELECTRICAL RESISTIVITY.**
- **NEGLIGIBLE EDDY CURRENT LOSSES** . . . Less heating.
- **UP TO 8 or MORE POLES ON A SINGLE FLAT FACE** (depending on size.)
- **LOW INCREMENTAL PERMEABILITY.**
- **INERT TO MOST CHEMICALS.**
- **LINEAR ENERGY VARIATION AND RETRACE WITH TEMPERATURE CHANGES** (to approximately 400°C).
- **AVAILABILITY IN PRACTICALLY ANY SIZE AND SHAPE** . . . at minimum cost.

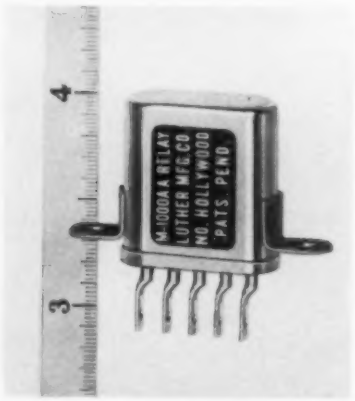
Write on company letterhead for Stackpole Ceramagnet Bulletin RC-11A.

HOW MORE FAVORABLE SHAPES OFTEN SIMPLIFY EQUIPMENT DESIGN

In many cases, Ceramagnet permits design improvement or space saving, thanks to the fact axial dimensions of the magnets may be reduced and radial dimensions increased correspondingly for more favorable shapes as indicated by the accompanying sketches.



STACKPOLE
Ceramagnet®
THE PERMANENT MAGNETS THAT ARE REALLY ***PERMANENT!***
STACKPOLE CARBON COMPANY • St. Marys, Pa.



resistance, with sepical coils available up to 10,000 ohm. Luther Mfg. Co., 7312 Varna Ave., N. Hollywood, Calif.

For more information—
Circle 69, inside back cover

Variable Transformer

Housed in a casting 3½ x 3½ in. dia, this unit provides a variable a-c voltage source for a 0-132 v, 1.0 amp, 132 va output from a 120 v, 60 cps, single-phase input. Superior Electric Co., 83 Laurel St., Bristol, Conn.

For more information—
Circle 70, inside back cover

Transformer

This transformer, Type LW136, is a double wound assembly with an isolated secondary on a single core. The primary consists of two windings arranged for either parallel or series connection. Any single-phase unit can be connected for either 120 v or 240 v, 50/60 cps input and can be used as a source of 0 to 30 v isolated output; either a 120 v or 240 v line corrector; or either a 120 v or 240 v limited range "buck-boost" variable transformer. Any three-phase, three-gang unit can be connected for either 240

(Continued on page 275)

The belt drive p. t. o. stood still . . .

An early-day tractor—International Harvester.

Minneapolis-Moline built this one.

until the splined shaft p. t. o. took over . . .

A late model Allis-Chalmers.

. . . providing flexible power transmission to all implements equipped with adaptable

BLOOD BROTHERS Jointed Drive Lines

History was made when engineers first replaced the "pulley p.t.o." with the universal-jointed shaft. For this concept of flexible power transmission was the key to Progress. Implements that had, until then, remained stationary in the fields now moved forward. And the whole implement industry moved forward too—building innumerable new, better machines driven through universally adaptable, flexible drive line assemblies. Working with the manufacturers, Blood Brothers has kept pace—by building stronger, better drive lines for every farm implement requirement. If *you* build implements, consult Blood Brothers for helpful cooperation.

FOR FARM IMPLEMENTS, MORE BLOOD BROTHERS UNIVERSAL JOINTS ARE USED THAN ALL OTHER MAKES COMBINED

TAKES POWER AROUND CORNERS

BLOOD BROTHERS MACHINE DIVISION

ROCKWELL SPRING AND AXLE COMPANY

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UNIVERSAL JOINTS AND DRIVE LINE ASSEMBLIES

Expanded metal can fit into your plans, too

Penmetal expanded metal used for delicate fabrics compartment of clothes dryer. Strong, smooth open mesh allows warm air to circulate freely.

Penmetal expanded metal, introduced at the planning stage, can often mean the difference between failure and success of products like these. That's why so many top designers are taking advantage of its valuable properties—why you should, too!

Decorative . . . its clean, modern look puts sales appeal in your product. Functional . . . the diamond truss pattern adds strength; permits the free passage of sound, heat and air. Made of sheet steel, which is slit and stretched from one to ten times its original width, expanded metal is up to 80% lighter than solid sheet of the same dimensions. And, cost is moderate.

Penmetal expanded metal comes in carbon steel, aluminum, stainless steel, Monel, Inconel, etc. Large or small mesh. Light or heavy gauge.

Next time you're planning a new product, or boosting an old one, don't overlook expanded metal. It offers a world of possibilities for exciting design. Send for descriptive catalog 509-EM.

PENN METAL COMPANY, INC.

General Sales Office:
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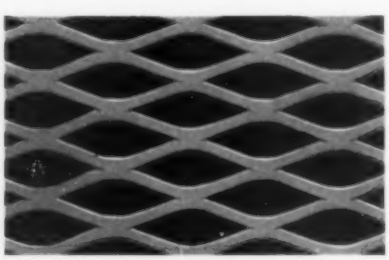
Plant: Parkersburg, W. Va.

District Sales Office: Boston, New York, Philadelphia, Pittsburgh, Detroit, St. Louis, Dallas, Little Rock, Seattle, San Francisco, Los Angeles, Parkersburg

Penmetal expanded metal adds strength with light weight and beauty to gossip bench.

TV speaker grille of expanded metal: handsome, strong, protective.



METAL MARK Penmetal 1869 OF QUALITY

a name to remember

or 480 v, 60 cps input and can be used as a source of 0 to 60 v isolated output; either a 240 or 480 v line corrector; or either a 240 or 480 v limited range "buck-boost" variable transformer. For manual or motor-driven service. Superior Electric Co., 83 Laurel St., Bristol, Conn.

For more information—
Circe 71, inside back cover

Double-row Jack Panel

A panel providing for 52 jacks mounted on $\frac{3}{8}$-in. centers is constructed of plastic, reinforced with steel. The $1\frac{3}{4}$-in. wide panel fits a standard 19-in. relay rack and comes with 52 normally closed circuit jacks. Mounting brackets, designation strips and jacks are plated to withstand a 50-hr salt spray test. Audio Development Co., 2833 13 Ave., S., Minneapolis 7, Minn.

For more information—
Circle 72, inside back cover

Heat-sensitive Switches

Electrical devices or apparatus can be protected against excess over-heating, creating a hazard or resulting in loss of material. This device opens the circuit should anything cause the temperature at the thermal cutout to rise above its opening point. Available in many types and styles of terminals. They may be installed in the heater element circuit, or if the heater cur-

(Continued on page 276)

Chemiseal® NYLON

Design with Chemiseal Nylon (duPont Zytel) which has the highest compressive strength, is the most rigid, has the best resistance to heat, abrasion, chemicals, solvents, oils and greases—and is the lowest priced of the standard Nylon compositions.

from prototype to production

U.S.G. supplies Chemiseal Nylon in forms to suit your part requirements at every stage from prototype to plant scale production.

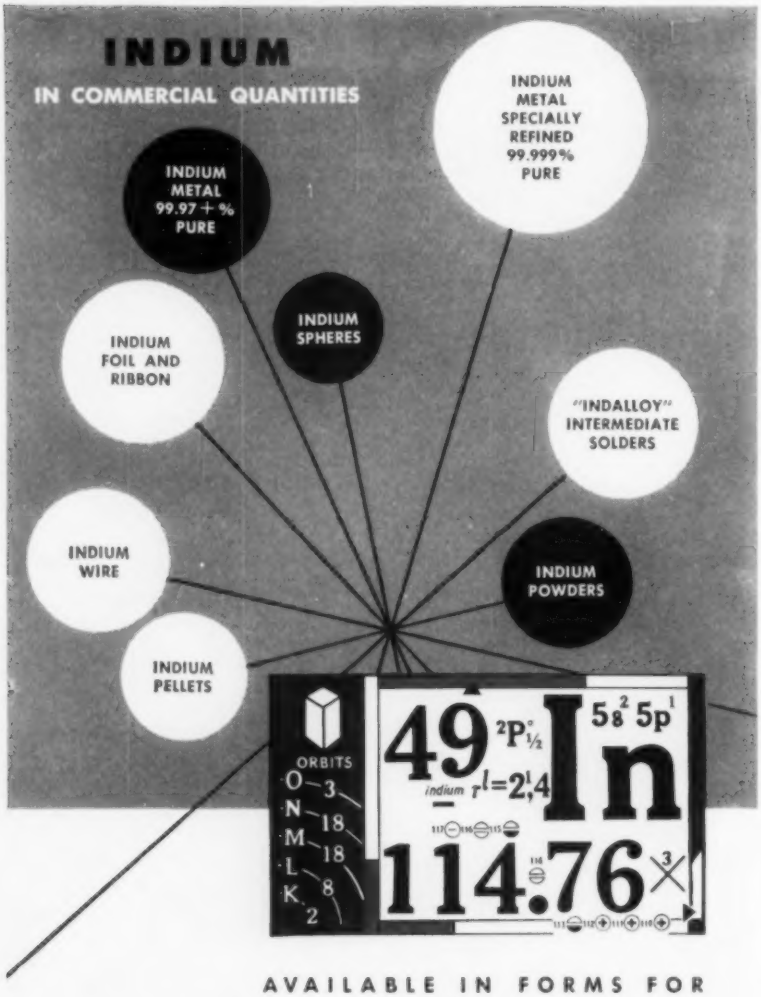
EXTRUSIONS—rods, tubing, special shapes (gear & cam blanks, L-shapes and channels) for producing parts in your own plant.

MACHINED PARTS—precision fabricated on high-speed automatics to your specifications. INJECTION MOLDED PARTS—volume production to close tolerances at lowest cost.

Use this complete service as a yardstick to determine the most economical part production methods for your needs. Bulletin N-1056.

United States Gasket Company
Camden 1, New Jersey

United States Gasket Plastics Division
OF THE GARLOCK PACKING COMPANY



QUALITY
at the Indium Corp. of America means: purity of metals, and strict adherence to specifications.

SERVICE
means prompt delivery to customers, and technical help in specific uses of Indium.

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means "forward looking" with respect to new products and new techniques.

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When you think of INDIUM, think of The INDIUM Corporation of America as your first source of supply.

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New Indium Bulletin . . . "Nomographic Charts of Pellets and Spheres . . . Weights per Thousand in Grams — with Alloy Analysis Equation."

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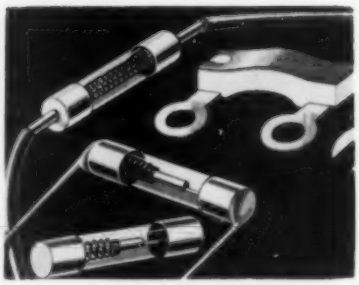
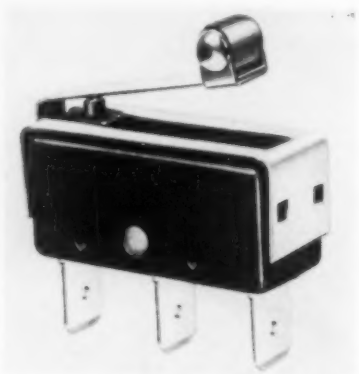


rent is controlled by a contactor, in the relay circuit. Bussmann Mfg. Div. McGraw-Edison Co., University at Jefferson, St. Louis 7, Mo.

For more information—
Circle 73, inside back cover



Switch for Ganging

These compact switches have a choice of operating forces from 3 to 12 oz on the pin. They are available with solder, screw, standard spade or junior tab terminals. Listed at 15 amp, 125-250 v a-c. Detroit Controls Corp., 800 Union Ave., Bridgeport, Conn.

For more information—
Circle 74, inisde back cover

Ball Bearings

A bearing having solid unbroken inner and outer raceways has burnished ball grooves. Radial and axial load capacities are increased because of the raceway construction. These

(Continued on page 280)

FORMER POWER UNIT SALESMAN

switches engine brands

AS BUYER...

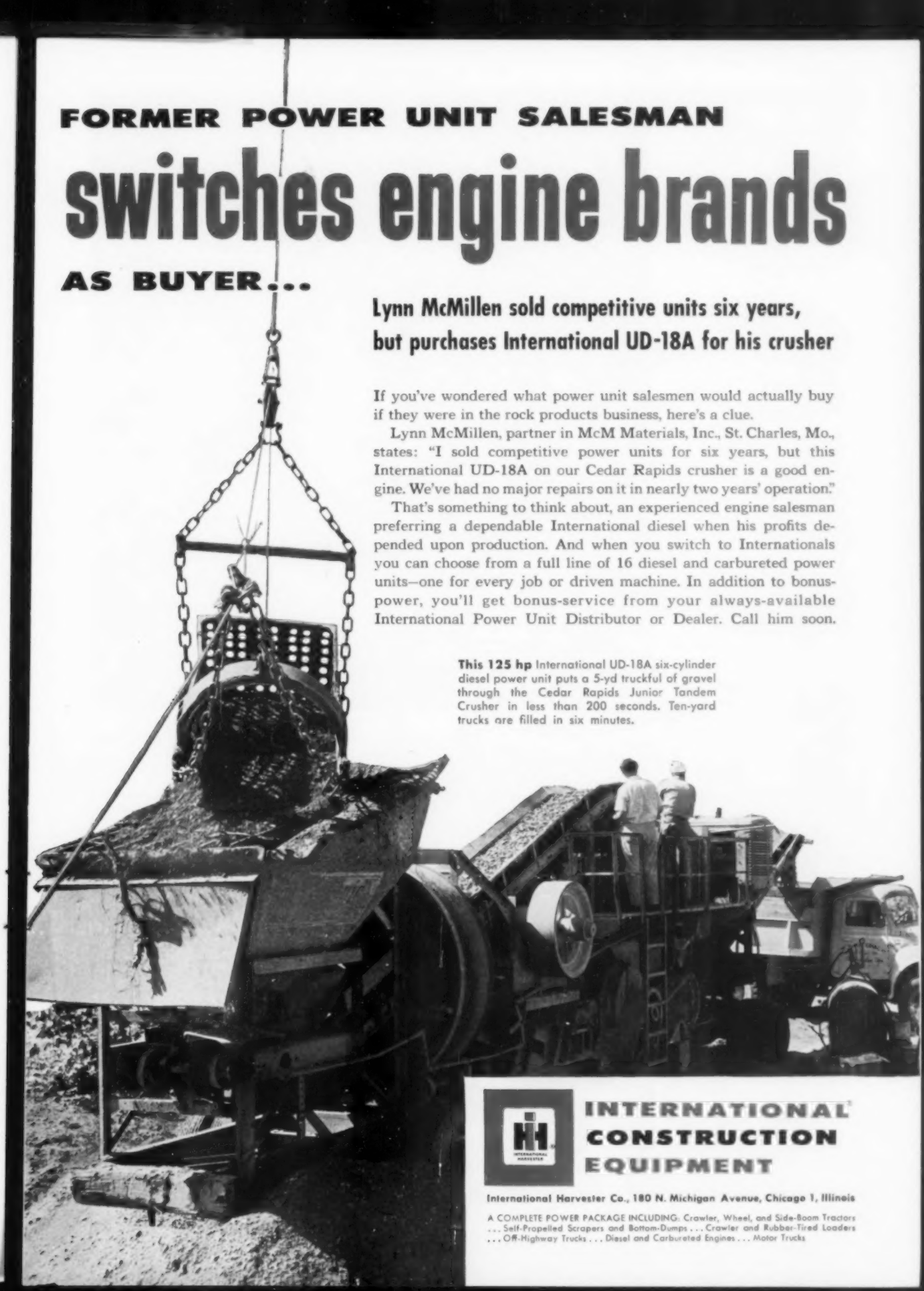
Lynn McMillen sold competitive units six years, but purchases International UD-18A for his crusher

If you've wondered what power unit salesmen would actually buy if they were in the rock products business, here's a clue.

Lynn McMillen, partner in McM Materials, Inc., St. Charles, Mo., states: "I sold competitive power units for six years, but this International UD-18A on our Cedar Rapids crusher is a good engine. We've had no major repairs on it in nearly two years' operation."

That's something to think about, an experienced engine salesman preferring a dependable International diesel when his profits depended upon production. And when you switch to Internationals you can choose from a full line of 16 diesel and carbureted power units—one for every job or driven machine. In addition to bonus-power, you'll get bonus-service from your always-available International Power Unit Distributor or Dealer. Call him soon.

This 125 hp International UD-18A six-cylinder diesel power unit puts a 5-yd truckful of gravel through the Cedar Rapids Junior Tandem Crusher in less than 200 seconds. Ten-yard trucks are filled in six minutes.



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International Harvester Co., 180 N. Michigan Avenue, Chicago 1, Illinois

A COMPLETE POWER PACKAGE INCLUDING: Crawler, Wheel, and Side-Boom Tractors ... Self-Propelled Scrapers and Bottom-Dumps ... Crawler and Rubber-Tired Loaders ... Off-Highway Trucks ... Diesel and Carbureted Engines ... Motor Trucks

Use WELDED STEEL for Greater Strength with Less Weight!

The weldment shown above is one half of the base for a 300,000 KW Steam Turbine...it weighs over 100 tons. This base, and the units shown at left, are typical of the thousands of Steel-Weld Fabricated parts and assemblies produced by Mahon each year for manufacturers of processing machinery, machine tools, and other types of heavy mechanical equipment. Are you taking full advantage of the economies offered by welded steel components in your products? In the design of almost any type of heavy machinery, or mechanical engineering project, there are parts and subassemblies that can be produced more economically and more satisfactorily in welded steel . . . because, in weldments you get greater strength with less weight, plus the additional advantages of greater rigidity and 100% predictability. When you consider weldments, you will want to discuss your requirements with Mahon engineers, because, in the Mahon organization you will find a unique source for weldments or welded steel in any form . . . a fully responsible source with complete facilities for design engineering, fabricating, machining and assembling . . . a source where design skill is backed-up by craftsmanship which assures you a finer appearing product embodying every advantage of Steel-Weld Fabrication. See Sweet's Product Design File for information, or have a Mahon sales engineer call at your convenience.

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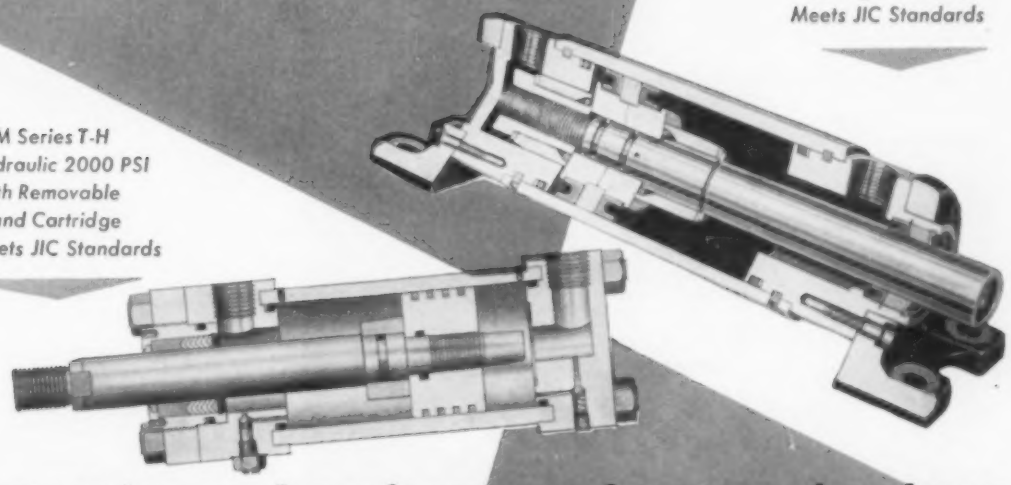
Engineers and Fabricators of Steel in Any Form for Any Purpose

MAHON

O-M CYLINDERS (AIR AND HYDRAULIC) *have everything*

O-M Tie-Rodless
150 PSI Air
Up to 1500 PSI Oil
With Internal
Locking Mechanism
Meets JIC Standards



O-M Series T-H
Hydraulic 2000 PSI
With Removable
Gland Cartridge
Meets JIC Standards

Construction and performance features that keep O-M cylinders right in the middle of AUTO-MATION

- Smooth, dependable operation at all practical speeds.
- Precision-honed, seamless steel body.
- Shock and vibration resistant.
- High-tensile alloy steel piston rod—ground, polished and hard-chrome plated.
- Multiple lip, self-compensating rod gland packing on all hydraulic cylinders.
- Self-compensating piston and rod packing on all cylinders, with packings available for fire-resistant fluids, also wide temperature ranges.
- Machined bearing bronze bushings for maximum service with minimum friction.
- O-ring static seals throughout – no flat gaskets to leak.
- Efficient wipers or scrapers on piston rods.
- Rolled steel precision machined end caps with ample sized ports.
- Adjusting needle for cushion control with ball checks for rapid full power starts.
- Versatile port orientation.
- Wide range of mounts and mounting accessories.
- Easily maintained – parts subject to wear can be repaired with minimum downtime.
- Plus many other features.

O-M Air and Hydraulic Cylinders are available in 1½" to 8" bores with standard and heavy-duty piston rods.

Mail coupon today for Bulletins 101A (O-M Tie-Rodless Cylinders) and 105 (O-M Series T-H Hydraulic Cylinders).

Engineering Service...

Consult an Ortman-Miller representative regarding your pneumatic and hydraulic problems. His broad experience with standard and special cylinder applications is available to you without cost or obligation. Use convenient coupon for name and address of O-M representative nearest you.

ORTMAN-MILLER MACHINE COMPANY

15 143rd Street, Hammond, Indiana

☐ Have representative call ☐ Send Bulletins 101A and 105

Name_____ Position_____

Company_____

Address_____

City_____ Zone____ State_____

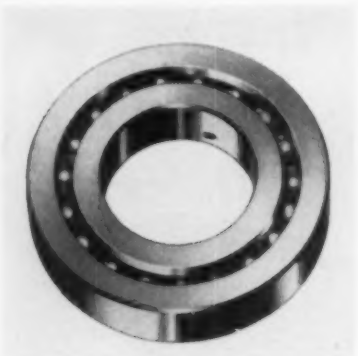
- **Easy to install...simple to service!**
- **No troublesome protective relays!**
- **No flashing contactors!**
- **No complicated electronic adjustments!**

Specially designed for machines where friction or torque is constant from high to low speed. Motor-generator set, controller and drive motor can be mounted independently, in any position.

- *One* control for all adjustments. 0 to 2400 RPM in 30 steps of 80 RPM, forward or reverse.
- Totally enclosed Streamcooled construction . . . vernier rheostat for infinite speed control between steps . . . jog switch for machine adjustments . . . reversing switch changes rotation . . . many other features.
- Ideal for use on conveyors, pumps, mixers, shaker screens, packaging machines, fans and blowers, farm machinery, governor controls, similar machines.

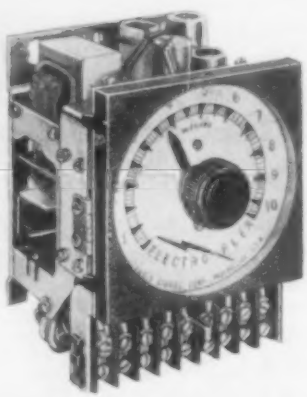
For complete engineering data write for Bulletin SP-600

BALDOR ELECTRIC COMPANY
4353 DUNCAN AVE. ST. LOUIS 10, MISSOURI



units can be furnished in single row, double row, and flanged types with controlled radial and axial play. Heim Co., Fairfield, Conn.

For more information—
Circle 75, inside back cover



Reset Timer

Designed to time short intervals from 0.05 to 10 sec. Timing accuracy is said to be maintained within 2% of the initial setting, taking into consideration voltage variations of −15% to 10%, ambient temperature changes of 70 to 140 F. The dial may be removed from the timer and located remotely. Eagle Signal Corp., Moline, Ill.

For more information—
Circle 76, inside back cover

Compact Timing Relay

A pneumatic timing relay is expected to meet the restricted space requirements of machine tool control panels and similar industrial applica-

(Continued on page 284)

MOLY NEWS

CLIMAX MOLYBDENUM COMPANY, 500 FIFTH AVENUE, NEW YORK 36, N. Y.

Super-Strength Structural Steels Boost Minimum Yield Strengths to 150,000 psi.

Seven steel companies in the U. S. are now producing a group of "Super-Strength Structural Steels" with considerably higher yield strengths than the well-known "High-Strength Low-Alloy" steels.

These Super-Strength steels offer minimum yield strengths ranging from 55,000 to 150,000 psi. And they have other useful properties, depending on composition, including strength at moderate temperatures, toughness at low temperatures, and good wear resistance. Almost all of these steels contain molybdenum as an essential element.

The search for steels with greater yield strengths has gone on for many years. Before about 1930, carbon steels with a yield point of roughly 30,000 psi were standard for almost all structural purposes. Then came the development of "High-Strength Low-Alloy" steels. They boosted minimum yields into the 50,000 psi range.

Now, the newer Super-Strength Structural Steels are being welcomed by designers, who see in them a way to solve one of their major problems — to minimize weight and size while retaining quality and reliability.

... For more information on these steels, including their trade names and compositions, circle number 1 on the coupon.

Moly's High Hot Strength Shows Promise for Jets and Rockets

Molybdenum-base alloys were described at the 1955 American Rocket Society annual meeting as having the greatest promise for true high-temperature operation.

Missile and powerplant designers are interested in moly mainly for its high temperature strength. Molybdenum-base alloys have been developed with higher useful strength at temperatures over 1600 F than any other presently known metallic material.

The jet propulsion field — including guided missiles and aircraft powered by rocket, ramjet, and turbojet engines — covers a tremendous variety of requirements and service conditions in respect to temperature, atmosphere, amount and type of stress, vibration, thermal shock, and prospective life. Molybdenum's properties make it a logical choice in many cases because it has:

1. High creep and rupture strength.
2. High tensile strength at high temperatures.
3. High modulus of elasticity.
4. A combination of high thermal conductivity, low specific heat, and low expansivity, which minimizes nonuniform temperature distribution and makes molybdenum insensitive to thermal shock.
5. High resistance to erosion by hot gases.
6. High melting point.

It seems safe to conclude that molybdenum-base alloys will become important structural materials in the jet propulsion field. And they will become essential for many parts operating at temperatures in excess of 1600 F.

... from "Molybdenum for High strength at High Temperatures," by R. Freeman and J. Briggs, JET PROPULSION, *February, 1957.*

For a copy of the complete article, circle number 2 on the coupon.

Moly Adds Strength and Corrosion Resistance to Titanium

Commercially pure titanium is fairly strong and highly corrosion-resistant. Alloying it, however, substantially increases these useful properties.

Molybdenum may prove to be one of the most useful of the alloying elements for titanium. Studies at Armour Research Foundation, for example, show that when molybdenum is used instead of vanadium, creep properties are greatly improved. At 1020 F, a stress of approximately 20,000 psi produces a creep rate of 10^{-4} in. per in. per hr in Ti-6 Al and Ti-6 Al-4 V, whereas 40,000 psi is required to produce the same creep rate in a Ti-7 Al-3 Mo alloy.

In summary, new alloy development is opening the way for titanium's extensive use in jet engines and air frames. Ti-Al-Mo alloys, for example, give better elevated temperature properties than the Ti-6 Al-4 V alloy now most widely used. And the alloy containing 7% Al and 3% Mo appears particularly promising.

Another Ti-Mo alloy contains 30 to 40% Mo. This alloy is claimed to resist boiling 40% sulphuric acid and boiling 20% hydrochloric acid as well as platinum, tantalum or gold. Such a retained beta alloy is weldable and could be fabricated into sheet. These corrosion-resistant characteristics would add to the value of all-beta Ti-Mo alloys.

... from "Molybdenum as an Alloy Addition for Titanium," by Harold Margolin, METAL PROGRESS, *February, 1957.*

For a copy of the complete article, circle number 3 on the coupon.

Moly Goes to Sea In A Sewer

Cast iron joint ring in pipe, before lowering into position. Joint rings were made by Alhambra Foundry Co., Ltd. and the concrete pipes poured by American Pipe and Construction Co.

Positioning 64 ton reinforced concrete sewer pipe sections puts quite a strain on the cast iron joint rings used to join them. Especially when the job is done under water at depths up to 210 feet.

Joint rings must be strong enough to withstand stresses developed when the pipe is drawn together, plus sufficient impact resistance to withstand handling and placement.

Those are good reasons why the County Sanitation District No. 2 of Los Angeles County specifies ASTM A 48, class 40 iron for the rings. In addition to the required 40,000 psi, tensile strength, and 2600 lb transverse strength minimum, (on a 1.2 in. test bar), the bar must be capable of deflecting at least 0.20 in. and the iron must contain at least 0.40% Cr, 0.60% Cu and 0.35% Mo.

Examination of pipe lengths after six years' service showed them in excellent condition. Equally good performance is expected from the most recent installations which extend some 8000 feet into the Pacific Ocean, and are believed to be among the largest in the country.

... For more information on the contribution of moly to toughness and shock resistance of cast iron, circle number 4 on the coupon.

Climax Molybdenum Company, Dept. 61,
500 Fifth Avenue, New York 36, N. Y.
I'd like more information on:
1 2 3 4

Name_____

Address_____

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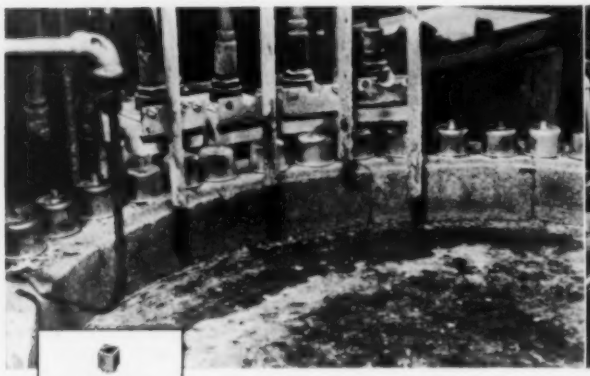
JOIN WITH HANDY & HARMAN SILVER BRAZING FOR PERMANENT PROFIT



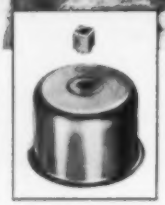


Table Lighter Cup – Spindle and cup are "painted" with a rich mixture of 180-mesh EASY-FLO 45 and HANDY FLUX in paste form. They are placed on revolving table which passes them under four gas-air burners in a 15-second heating cycle. The closing-spring latch is joined to the top of this lighter by torch brazing with EASY-FLO 45 Rod.

Pocket Lighter Top Assembly – This consists of the lighter top, wick housing, flint housing and cover spring housing, and requires three brazed joints. Parts are first assembled and dipped in HANDY FLUX. Next, operators place a single wire preform (EASY-FLO 45) which covers all three joints. Brazing is automatic as table carries assemblies under burners.

How RONSON® Makes Cigarette Lighters by the Hundred Thousand with EASY-FLO 45 Brazing

Here is a real "example in volume" of the advantages of Handy & Harman silver alloy brazing. Ronson Corporation, manufacturer of the world's best known lines of pocket and table lighters, meets its high-production joining requirements with simplicity, sureness and economy.

Everything Ronson requires – life-of-the-lighter strength, leak-tight joints and fast, easy assembly – is provided by silver brazing with EASY-FLO 45 and HANDY FLUX. Joining thousands of assemblies a day, for both table and pocket model lighters, is economical. The cost per joint is reckoned in mills.

This is an example that tells the silver brazing story all by itself – speed, strength, economy, low labor costs – all help make a product that everyone knows and millions use. That's how Handy & Harman alloys help make Ronson a name to depend on. How about your product? Could it use this remarkable joining method? Find out for yourself. Call Handy & Harman today.

TAKE A LOOK

. . . at Bulletin 20. This concise introduction to silver alloy brazing talks about joining methods, as well as joint design and economies that can be enjoyed with EASY-FLO brazing. We'll send you a copy whenever you request it.

Your NO. 1 Source of Supply and Authority on Brazing Alloys

HANDY & HARMAN

General Offices: 82 Fulton St., New York 38, N. Y.

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NEW, COMPACT Century 48-FRAME Fractional HP MOTORS

INDUSTRIAL QUALITY for all applications

take less space...
weigh less...
perform better!

ROTOR

Rotor bars, end rings, and fans integrally pressure-cast of virgin aluminum. Rotors dynamically balanced to very close limits; meet strict quiet-motor requirements.

INSULATION

Heavy vinyl acetal insulated wire, tough mechanically, thermally, and dielectrically, has excellent moisture resistance, highest uniformity. Stator core slots lined with cells of DuPont Mylar bonded to all-rag electrical paper.

BEARINGS

Sleeve: pressed into place in bracket which has been bored true in single set-up operation. Finish boring operation assures proper bearing surface and concentricity. *Ball:* single-shielded, precision fitted in brackets.

LUBRICATION

Sleeve bearing type: wool yarn wicking provides constant oil supply to oil groove. Inner sump cup retains excess oil which is tapped by felt wicks extending into the wool yarn. *Ball bearing type:* standard construction permits re-greasing.

GOVERNOR and SWITCH

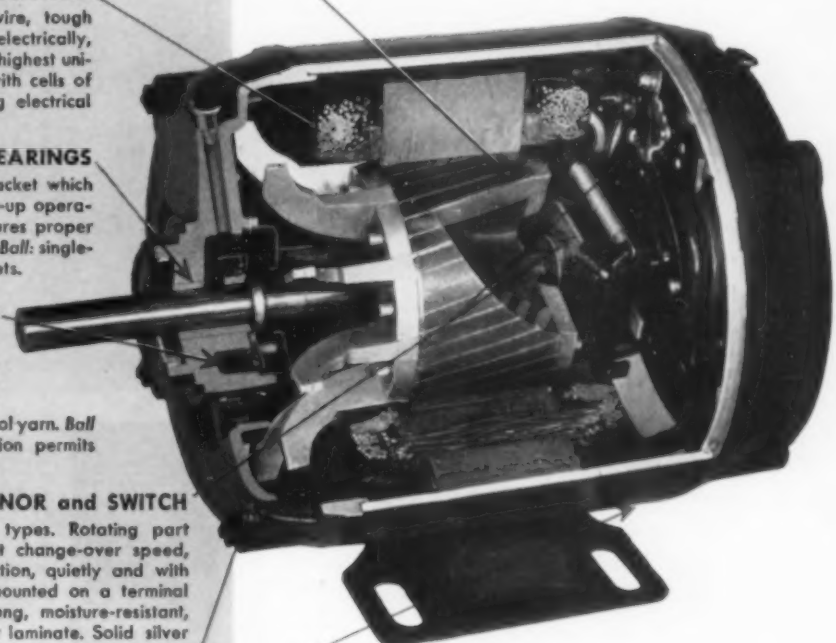
For capacitor and split phase types. Rotating part securely press-fitted to shaft. At change-over speed, governor operates with snap action, quietly and with no flutter. Stationary switch is mounted on a terminal plate; plate is GLASTIC, a strong, moisture-resistant, arc-resistant glass-filled polyester laminate. Solid silver contacts are used.

BEARING BRACKETS

Pressure cast in special aluminum casting alloy. Stress relieved for permanent stability. Strong internal ribbing for strength, and smooth outside surface.

FRAME

Stator frame rings formed of one-piece heavy rolled steel. No frame openings; windings fully protected. Rabbet fit faced and bored true to provide proper alignment of bracket and a concentric air gap. Heavy formed steel feet welded to frame ring.



Century Industrial Quality means *design* that does not compromise dependability to gain slight cost advantages... sturdy construction provides the stamina which assures continuous operation. 48-Frame Motors now available from 1/20 to 1/3 HP... Performance-Rated to your needs... with weight savings up to one-third!

Test one of these motors for yourself. Call or write your nearby Century District Sales Office or Authorized Distributor. Send for new bulletin 1-1P1.

Performance-Rated® MOTORS
1/20 to 400 HP

CENTURY ELECTRIC COMPANY

1806 Pine Street • St. Louis 3, Missouri • *Offices and Stock Points in Principal Cities*

64

time to re-examine

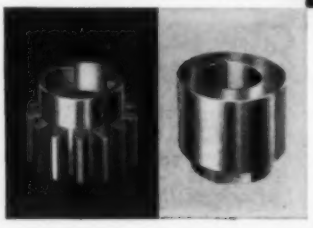
BEARING APPLICATIONS

Striking cost reductions in bearing applications in many mechanical products are made possible by the use of Bunting Sintered Powdered Metal Bearings and parts.

Bunting engineering counsel can guide you in the selection of designs and alloys that will provide bearings of exactly the type, design and material that will fully meet both cost and functional requirements, whether the material be Cast Bronze or Sintered Metal.

A competent group of Bunting Sales Engineers in the field and a soundly established Product Engineering Department put at your command, comprehensive data and facts based on wide experience in the designing and use of Cast Bronze and Sintered Powdered Metal Bearings and parts.

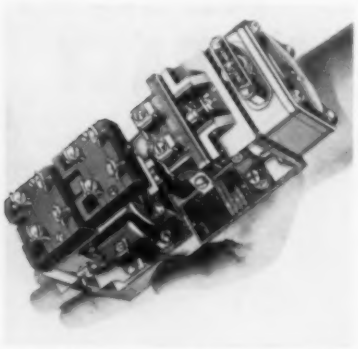
Write for catalogs and your copy of the new 24 page Bunting Engineering handbook of Sintered Powdered products and their composition, manufacture and application.



Bunting®

BUSHINGS, BEARINGS, BARS AND SPECIAL PARTS OF CAST BRONZE AND POWDERED METAL

The Bunting Brass and Bronze Company • Toledo 1, Ohio • Branches in Principal Cities



tions. Measures 2½ by 7⅞ in. high. Adjustable timing ranges from 0.2 sec to 3 min with an accuracy of 10%. Can be converted from on-delay to off-delay operation, or the reverse, in the field, without need of special tools. A-c and d-c models. Square D Co., 4041 N. Richards St., Milwaukee 12, Wis.

For more information—
Circle 77, inside back cover

Right-angle Gear Motors

These gear motors meet AGMA specifications, and may be foot or ring mounted. From ¼ through 5 hp in all enclosures. Gear case and motor housing are aluminum alloy. Characteristic of gear motors, has good heat transfer properties, and is corrosion-resistant. Double-positive oil seals are used on input and output shafts to prevent

leaks. Sterling Electric Motors, Inc., 5401 Telegraph Rd., Los Angeles 22, Calif.

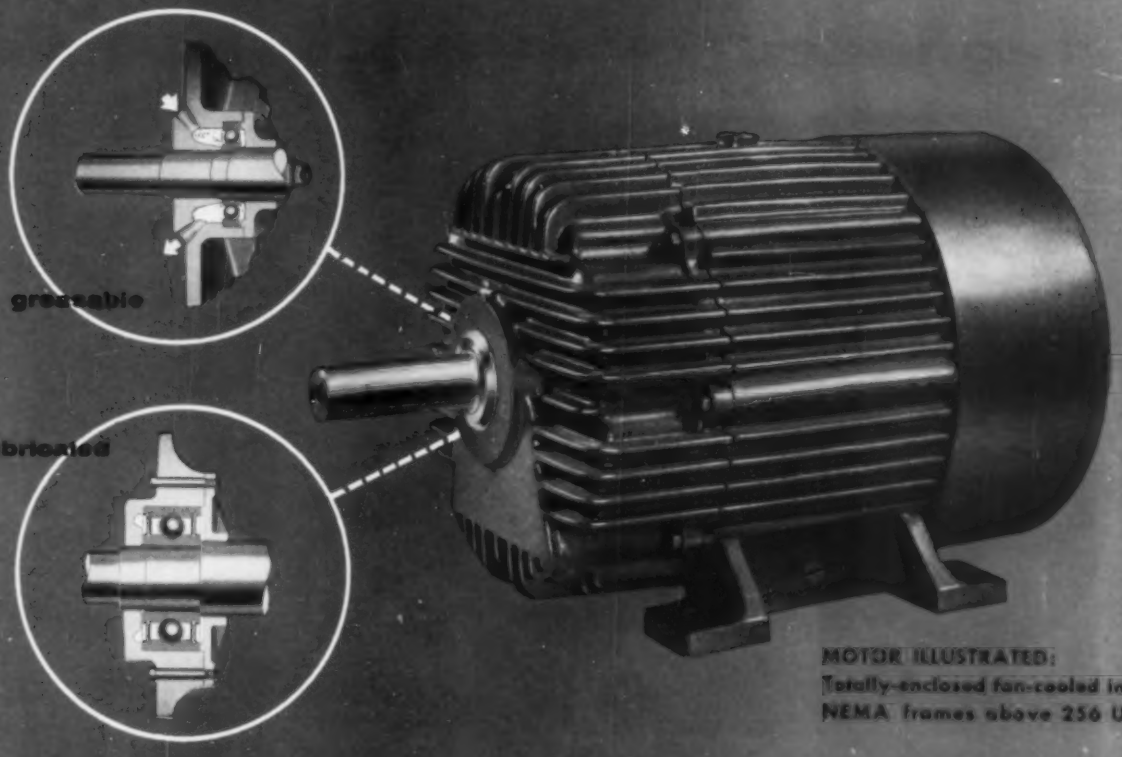
For more information—
Circle 78, inside back cover

Xenon-filled Thyratron

An 18 amp d-c thyratron has been designed for motor speed control, resistance welder control, and incandescent light control. The tube is Xenon-filled, and is said to be quick starting

(Continued on page 288)

YOUR CHOICE of motor bearings . . .



—when you specify ELLIOTT Crocker-Wheeler Type N integral horsepower motors

Whatever your operating conditions or maintenance practice, Crocker-Wheeler offers the motor bearing best adapted to your needs or preference.

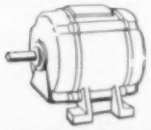
The Open Greasable type
requires only infrequent lubrication. All old grease is positively flushed out, eliminating risk of forcing grease into motor interior. An external grease reservoir helps seal and protect the bearing. The inner cap and grease reservoir prevent rust or corrosion from within.

Prelubricated bearings
are furnished for applications requiring operation without regular service lubrication. They are sealed cartridge-type, factory grease-filled, with inner protective cap.

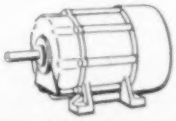
Choice of bearings
is another design feature of the new Elliott Type N motor line. These motors are honestly new—inside and out. We think you'll agree that they incorporate every important feature that distinguishes a modern motor.

W7-1

OTHER C-W TYPE N MOTOR ENCLOSURES


Totally-enclosed non-ventilated

Dripproof Protected

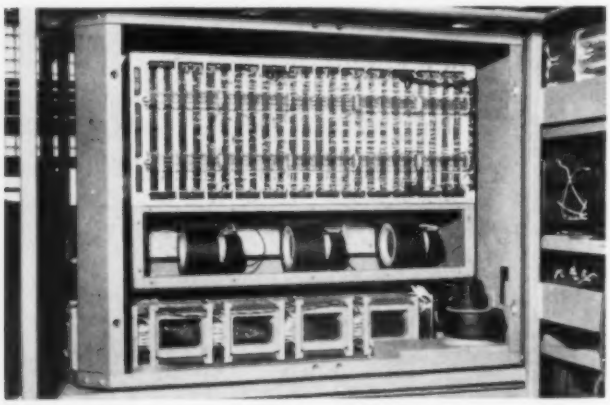

Totally-enclosed, fan-cooled Frames 256 U and smaller

ELLIOTT Company
CROCKER-WHEELER DIVISION
Jeannette, Pennsylvania

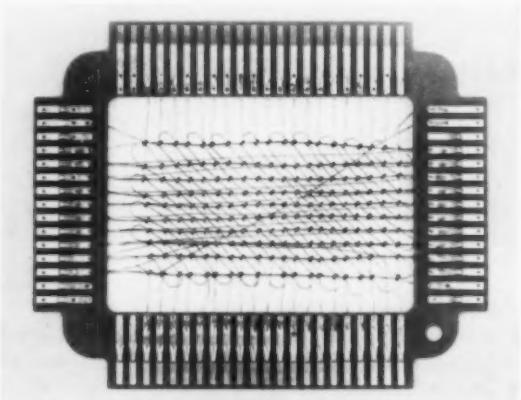
We will be glad to send a copy of this new booklet describing the complete line of Elliott C-W type N motors. Ask for Bulletin PB 6000-6.

THE NATIONAL SCENE

KEEPING "ELECTRONIC BRAINS" FROM LOSS OF MEMORY. One of science's greater marvels is IBM's 705 Electronic Data Processing Machine—which makes intricate calculations and logical decisions in millionths of a second. Heart of this electronic "wizard" is its main magnetic core memory. Designed for use with the machine's high-speed printer is the IBM 760 Control and Storage Unit containing its own core memory of 1,000 positions which allows central processing to continue in the 705 while other data are being printed. Helping the 760 remember what information is to be printed is a job for PHENOLITE® Laminated Plastic. PHENOLITE's unique combination of properties makes it ideal for this application.



MOST ADVANCED FORM OF ELECTRONIC STORAGE. The 1,000-position core memory for the IBM 760 Control and Storage Unit—a portion of which is shown here—consists of pinhead size cores strung on copper-wired frames of PHENOLITE. Electrical impulses, passing through wires, alter the magnetic state of cores so that a group of them stands for a word or figure. Reversing the process recalls information from storage. PHENOLITE frames safeguard the circuit and permit stacking of core planes as shown.



PHENOLITE MEETS CRITICAL STANDARDS. Core frames like the one shown are punched out of laminated PHENOLITE by IBM. Each frame has printed circuit type terminal strips and soldered connections. PHENOLITE proves an ideal material for this application because it is mechanically strong and stiff, punches cleanly, etches well, remains flat, has high dielectric properties and withstands the heat of dip soldering.

NATIONAL CAN HELP YOU reduce unit product cost or improve product performance at no added cost. Here's why . . . You can select the "one best material" from over 100 grades of PHENOLITE, Vulcanized Fibre and National Nylon—without compromise in properties or cost. You can simplify production and purchasing with the timed delivery of 100% usable parts—from a single reliable source. You gain competitively with National's new materials and grades—the direct result of programmed materials-research.

You benefit by calling National first. Check Sweet's PD File 2b/Na, the Telephone Directory Yellow Pages, or write Wilmington 99, Delaware. Dept. H-7.

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VULCANIZED FIBRE CO
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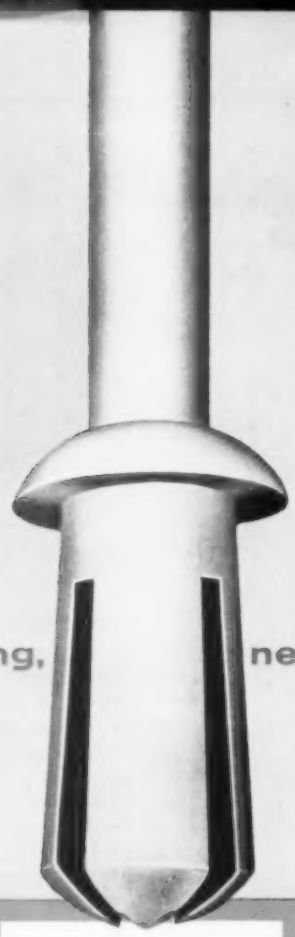
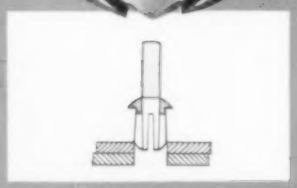
NATIONAL FIBRE CO. OF CANADA, LTD., Toronto 3, Ont.

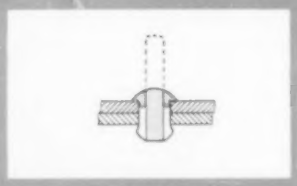
time-saving, neat-appearing FASTEX®



Plasti-Rivets®

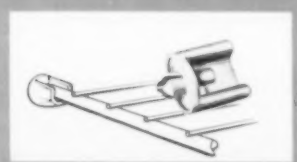


JUST SET . . .



. . . AND DRIVE

Plasti-Rivets fasten molding onto coin-operated machines, are available in colors to complement product color scheme.



The Plasti-Rivet principle has been incorporated in Plasti-Supports (TM); form ideal refrigerator shelf-supports.

Molded of thermoplastics, Plasti-Rivets fasten from one side with a single blow. The prongs expand when the integrally molded pin is driven, providing a positive, vibration resistant lock. Blind assembly is simplified, products improved and time saved while costs are reduced. Plasti-Rivets can withstand a direct shear of up to 500 pounds. Available in a choice of decorator colors and shapes, Plasti-Rivets will never mar or scratch your product's surface. For a firm, positive fastening, specify easy-to-use Fastex Plasti-Rivets.

Write for your free sample packet and informative brochure listing 25 standard Plasti-Rivets. See how simple and economical blind fastening can be.

Fastex Plasti-Rivets Create Assembly Savings in: non-conductive fastening of electrical products, name plate attachments, appliance shelf fastening, rustproof fiberglass awning fastening, and color-matched fastenings for practically any product.

FASTEX / **DIVISION OF ILLINOIS TOOL WORKS**
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Division of Canada
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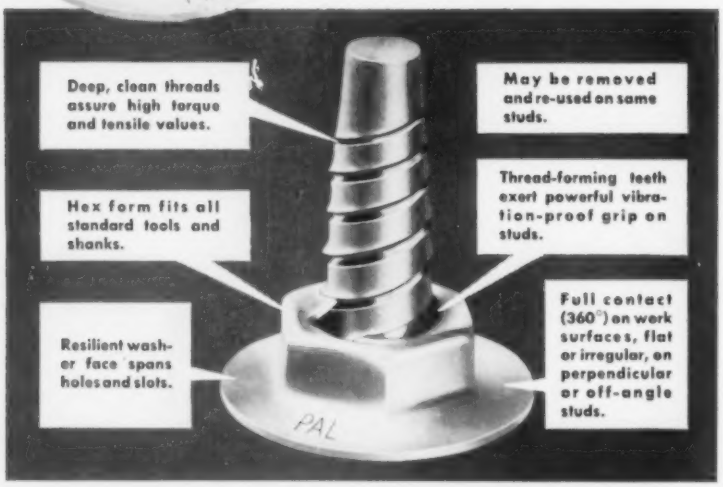
Toronto, Ontario

itw

New! PALNUT®
SELF-THREADING NUTS

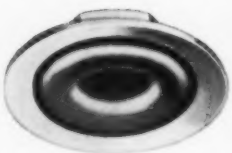
Make their own threads on studs — easily, quickly


Deep, clean threads assure high torque and tensile values.
Hex form fits all standard tools and shanks.
Resilient washer face spans holes and slots.
May be removed and re-used on same studs.
Thread-forming teeth exert powerful vibration-proof grip on studs.
Full contact (360°) on work surfaces, flat or irregular, on perpendicular or off-angle studs.
PAL

Ideal for Nameplates — Ornaments — Moldings with die-cast or cold-forged studs

Now . . . low-cost, plain studs become strong, vibration-proof threaded assemblies by simply fastening with the new PALNUT Self-threading Nuts. You eliminate the high cost of threaded studs—your fastening operation does the thread-cutting while tightening. No special tools needed—high-speed assembly is obtained with standard tools and methods.

PALNUT Self-threading Nuts are made of spring-tempered steel, comprising a thread-cutting lock nut and flat washer in one piece. Parts are pulled up tight with a resilient spring locking action that will not loosen in service. Available in sizes for 1/8", 3/16" and 1/4" unthreaded studs. Write for free samples and descriptive literature.

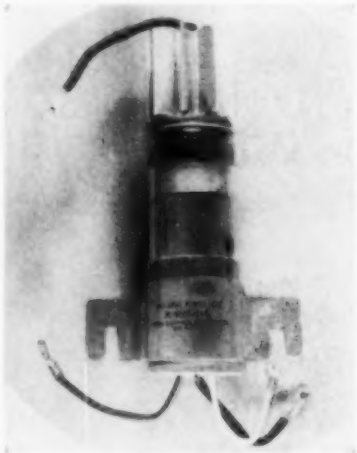


Also available with "bonded-in" plastisol compound to seal out water and dust.

THE PALNUT COMPANY, 65 Glen Road, Mountainside, N. J.
Subsidiary of United-Carr Fastener Corporation

PALNUT® LOCK NUTS FASTENERS PAL®

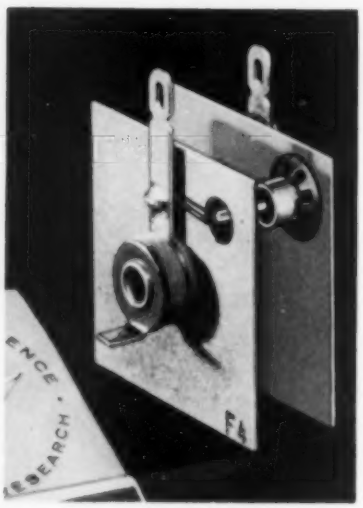
Quick, secure fastening at low cost



and to possess wide temperature limits.

Ratings are: filament volts, 2.5 v; filament current, 31 amp; maximum peak inverse volts, 1250 v average anode current, 18 amp; peak anode amp, 100 amp; anode current averaging time, 4.5 sec, and filament heating time, 60 sec. National Electronics, Inc., Geneva, Ill.

For more information—
Circle 79, inside back cover



Silicon Rectifier

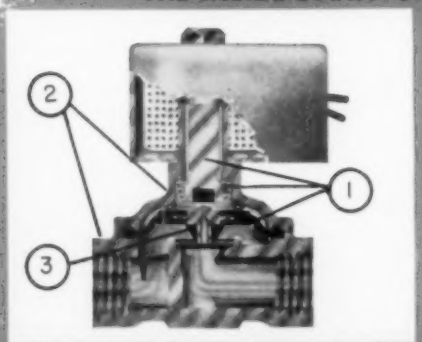
A direct and universal replacement unit for all existing selenium stacks up to 500 ma. Features eyelet construction, eliminating the need for special sockets, drilling or conversion kits. Unistac TV500 employs a silicon diode mounted on a finned heat exchanger for optimum convection cool-

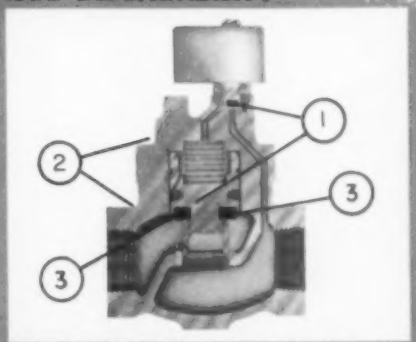
(Continued on page 292)

new complete line of
ASCO 2-way solenoid valves
now available in full range through 3" sizes

Now specifying engineers may select from ASCO's new line of general purpose packless valves in full size range from ⅜ to 3 inches; pressures to 350 p.s.i. Study these valve cross sections and see why ASCO design means dependability in flow-control for air, gas, water, light oil and other non-corrosive fluids.

THE INSIDE STORY OF ASCO DEPENDABILITY





Simplicity in operation. Normally Closed Types (shown in energized position) Pilot port (under core) is open, releasing pressure on top of diaphragm (or piston) to outlet side of valve. Line pressure raises diaphragm (or piston) to open main port and permit full flow. When solenoid is de-energized, pilot port is closed, and full line pressure is applied to diaphragm or piston, providing seating force for tight closure.

Bulletin 8210A ⅜"–¾" sizes

1. Simplicity in construction. Only three operational parts: all stainless steel core, stainless steel spring, Hycar diaphragm (for handling all common liquids and gases).
2. Ruggedness. Forged brass bonnet and body insure freedom from porosity.
3. Tight Shut-Off. Assured by resilient disc construction.
4. Compactness. 2¾" face to face; 3¼" pipe center line to top of solenoid; 3 13/16" overall height. (Normally closed, ⅜" x ½" sizes.)
5. Mountable in any position, normally open or normally closed.

Bulletin 8210A 1¼"–3" sizes

1. Simplicity in construction. Even in larger port sizes, moving assemblies have been held to two—bronze piston and stainless steel core.
2. Ruggedness. Extra heavy duty bronze body and bonnet, plus heavy duty operating parts.
3. Tight Shut-Off—assured by resilient disc construction.
4. Elimination of water hammer—assured by slotted "V" type discs.

All sizes have full area ports, continuous duty coils designed for low temperature rise and long life, and are available normally open or normally closed with standard, water tight or explosion proof solenoid.

Whatever the crucial factor in your flow-control application—reliability, compactness, high cycling rate—there is an ASCO valve that meets your need.

Write for Catalog 201 covering ASCO line of solenoid valves.

Automatic Switch Co.
54-G Hanover Road, Florham Park, New Jersey
FRontier 7-4600

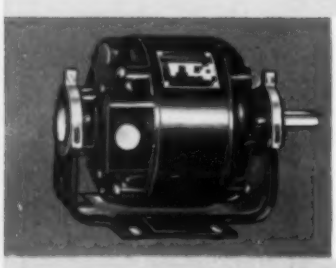
ASCO

100 ENGINEERS AVAILABLE

Yes, 100 engineers are ready to go to work for you *right now*. They're Emerson-Electric's *motor specialists*...available to help you in the development of your product—from idea through production.

Every Emerson-Electric motor is custom-engineered to suit your specific needs—*designed* for you, *produced* for you and *priced* for you. It is no longer necessary to design your product around a *standard* motor. Emerson-Electric engineers will help you get the product you want with a motor that exactly suits your purpose... a custom-engineered motor.

Call, wire or write Dept. M-61 today. The Emerson Electric Mfg. Co., St. Louis 21, Mo.



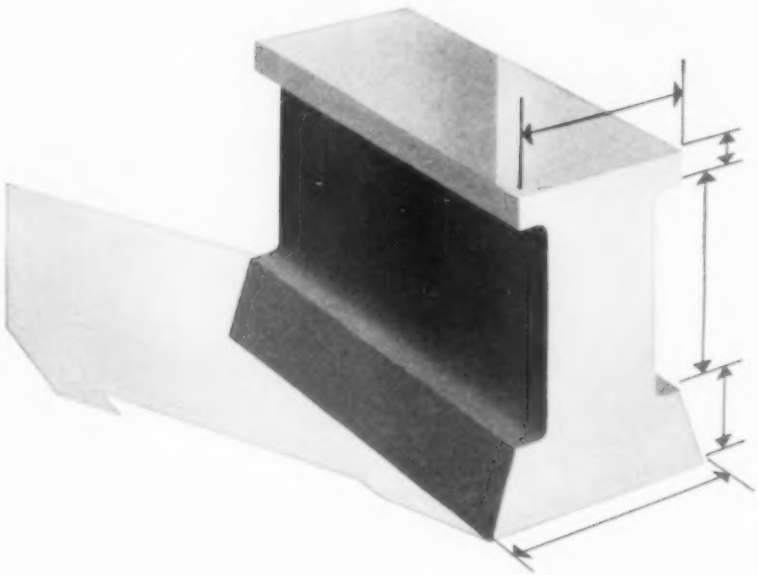
Every Emerson-Electric motor is custom-engineered to meet your *exact* requirements.

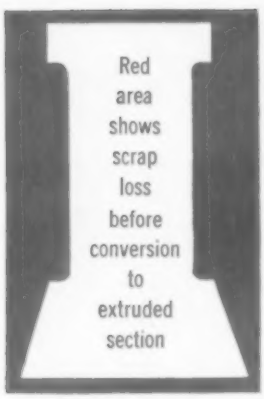
EMERSON-ELECTRIC

of St. Louis

Since 1890

Cost per clamp cut from $1.06 to 58¢ with J&L hot extruded cold drawn section





This manufacturer cut the cost of contact clamps 45% by converting to J&L extruded sections. Previous cost of $1.06 per part involved costly milling and scrap loss from cold drawn 1½" x 1" flats.

Here's how extruded sections can cut your cost:

1. Eliminate machining and finishing operations.
2. Reduce scrap losses almost to zero.
3. Eliminate cost of casting and forging intricate sections.
4. Reduce inventories because extrusions are quickly available.

Investigate this new production technique for your shape profiles—within present limits of a design which can be inscribed in a three-inch circle. Available in a wide range of carbon and alloy steels. For specialty alloy and tool steels, submit inquiry. Get complete details by writing to the Jones & Laughlin Steel Corporation, Dept. 409, 3 Gateway Center, Pittsburgh 30, Pennsylvania.

Jones & Laughlin
STEEL **. . . a great name in steel**

HIGHEST QUALITY

PROMPT DELIVERY

DIAMOND Ornamental PERFORATED METAL

Grecian Cane Design — 42% Open Area

Side Stagger Design — 40% Open Area

Tile Cane Design — 52% Open Area

Need Holes in Metal Sheets?

Several considerations must usually be observed. The design should be attractive in appearance, with adequate open area, while still, for some purposes, affording suitable concealment of what lies behind or underneath.

WHEREVER perforated metal is required, and it has thousands of applications today, you'll do well to contact DIAMOND. Forty years of widely diversified experience and hundreds of modern tool arrangements, enable us to give unsurpassed quality and delivery at competitive prices.

Catalog 39 shows many interesting applications and contains complete illustrated working data. No charge or obligation, but kindly state business connection.

DIAMOND MANUFACTURING CO.
WYOMING WILKES-BARRE AREA PENNA.

West Coast Plant, Diamond Perforated Metals Co.
17915 So. Figueroa St., Gardena, California
Los Angeles Area

ing. One, in a half-wave circuit, will deliver 500 ma and 130 v d-c, with an input of 117 v rms. International Rectifier Corp., 1521 E. Grand Ave., El Segundo, Calif.

For more information—
Circle 80, inside back cover

Sampling Switch

This unit has radial terminals and is available with one or two poles and up to 120 shorting channels or 60 non-shorting channels per pole. It is equipped with a precision machined ball bearing output shaft. Dimensions are 2.620 x 1.332 in. length, plus hub extension, $\frac{3}{4}$ in. x $\frac{1}{2}$ in. length and shaft $\frac{1}{4}$ in. dia. General Devices, Inc., Princeton, N. J.

For more information—
Circle 81, inside back cover

High-Rated Motor Capacitors

Higher capacity and voltage ratings with small increase in height and no increase in base dimensions are features of these capacitors, used to improve the power factor of single phase

(Continued on page 296)

Wiggins

INST-O-MATIC CONNECTION

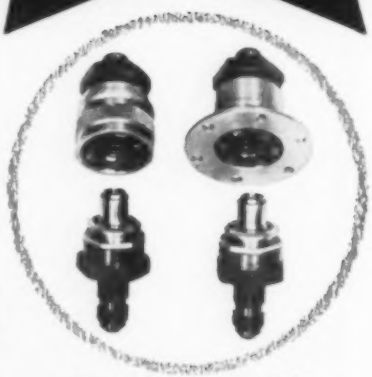
quick disconnect

3000 psi

USE WIGGINS CONNECTIONS FOR

OIL
AIR
WATER
L P GAS
HYDRAULIC OILS
PNEUMATIC
GASOLINE
REFRIGERATION
COOLANTS
HELIUM
NITROGEN
AMMONIA
KEROSENE
FUEL OIL
DIESEL OIL

SIZES: ¼" to 2½"



Manual Quick Disconnect (Push-Pull Positive Action)

Automatic Quick Disconnect (Breaks Away at Pre-determined Weight Load)

The authority on connectors. Engineered for Reliability.

Wiggins

Write for information.

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3424 E. Olympic Blvd.,
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"PONY POWER" MOTORS

that give stamina to your products

Lamb Electric ***fractional*** horsepower motors, like the small horses of the famed western-pioneer-day Pony Express, are developed for *stamina.*

Their dependability, and efficiency (optimum weight-size-horsepower ratio) are qualities that result from proper design and careful manufacture by personnel with many years of experience in the small motor field.

May we demonstrate how Lamb Electric Motors can bring these advantages—and also perhaps lower costs—to *your* products?

THE LAMB ELECTRIC COMPANY • KENT, OHIO

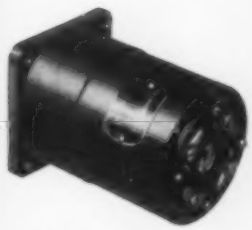
A Division of American Machine and Metals, Inc.

In Canada: Lamb Electric — Division of Sangamo Company Ltd. — Leaside, Ontario

Lamb Electric

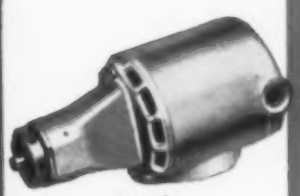
SPECIAL APPLICATION FRACTIONAL HORSEPOWER **MOTORS**

A rugged high-torque, high-speed motor.



Radar voltage regulator gear motor.

Motor with efficient spur gear speed reducer.



Motor for high-speed grinder.

If you are interested in any of the above motors write and we shall be glad to send full information.

The Payoff Power *is Chrysler*

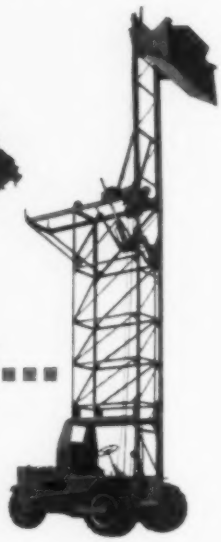
Stoop...

IT'S A MATERIALS HANDLER . . .

Scoop...

A FRONT-END LOADER . . .

Boom...



AN ELEVATING MACHINE . . .

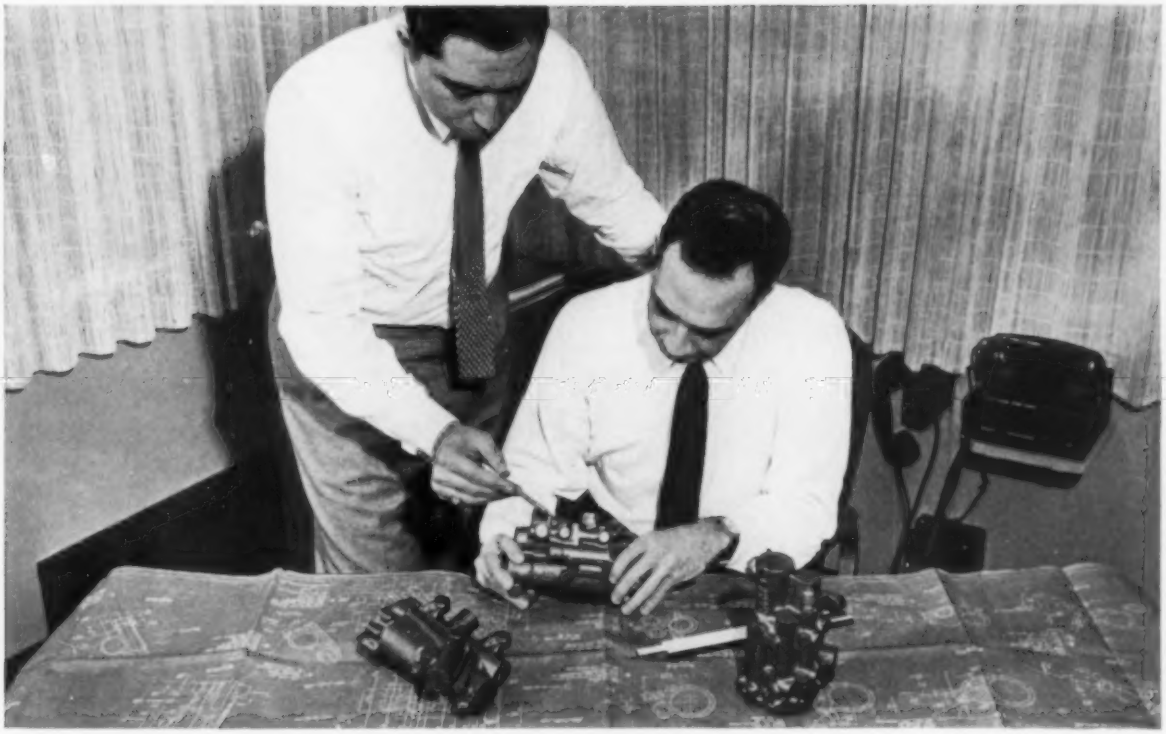
Here's a real "quick change" artist—the Model C Scoopmobile! Nine different attachments—all of which can be changed and operated by one man—give it exceptional on-the-job versatility. Single tail wheel provides greater maneuverability—especially in close quarters. Chrysler Power gives it extra guts and stamina—at lower operating and maintenance cost.

CHRYSLER INDUSTRIAL 33, in-line 6 Engine (265 cu. in. displacement) powers the Model C Scoopmobile—and many other makes of equipment in the construction and materials handling fields. There are four Chrysler in-line 6s, two V-8s—ranging from 230 to 354 cu. inch displacement. For detailed information about Chrysler Industrial Power write: Dept. B7, Industrial Engine Division, Chrysler Corporation, Detroit 31, Michigan.

Chrysler

INDUSTRIAL ENGINES

INDUSTRIAL ENGINE DIVISION • CHRYSLER CORPORATION



CORE SHIFTING ELIMINATED

in casting stainless steel jet afterburner components

1

2

Cooper Alloy Advanced Casting Know-How Solves Alignment Problem, Cuts Machining Costs For Pratt & Whitney

PROBLEM: To produce precise tolerances on this complicated jet igniter afterburner valve casting for Pratt & Whitney Aircraft. Previous method involved use of core mold and five cores. Core shifting was the main problem as off-symmetry pieces caused a serious and costly problem of machining. Troubles were further accentuated in that the alloy (a very brittle material) was non-repairable. With welding impossible and 100% X-Ray and Zyglo required, defects could not be tolerated.

SOLUTION: (a) Development and use of 4 shell cores, all placed in one half of the mold and in an unmovable position, overcame problem of shifting and held close tolerances (Fig. 1). (b) Use of Shellcast® process gave a better surface finish with no defects. (c) To prevent mold deflection and loss of dimensional accuracy from weight of metal, shell molds were backed up with a special sand (Fig. 2) which hardens immediately when gassed with carbon dioxide.

Since making the change to shell molds and cores, and with the use of the CO_2 process, accuracy and finish are excellent. In overcoming core and mold shifting by the use of advanced know-how methods, off-symmetry pieces were eliminated and costs cut for Pratt & Whitney.

Cooper Alloy, a specialist in stainless steel for 35 years, is still a pioneer in the development and application of new techniques for handling this tricky metal. Next time you have a tough casting problem, think of Cooper Alloy. *Send for your copy of our folder "Advanced Casting Know-How" today.*

COOPER ALLOY

Corporation • Hillside, New Jersey

FOUNDRY PRODUCTS DIVISION

THIRTY-FIVE YEARS OF STAINLESS STEEL PIONEERING

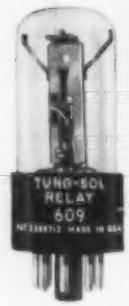
"Just Doing a Little Exploring!"

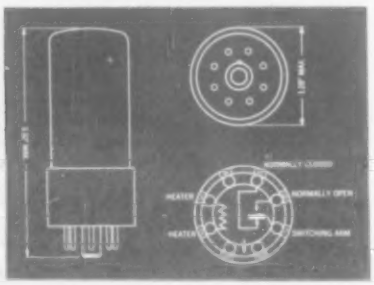
If you're the man whose product needs this Tung-Sol Relay – then it's you I'm exploring for

Tung-Sol produces a line of thermal relays in the general operating range characterized by the Type 609. Snap action contacts and extremely sensitive actuating heater elements provide uniform cycling. Operating principle permits manufacture of time delay relays and relays which function on small differential of voltage and current. Compact and lightweight, Tung-Sol relays are ideal for instruments and electrical equipment application.

NOMINAL DESIGN CONSIDERATIONS

Contact capacity.....1 amp 30 volt resistive
Contact arrangement.....SPST (NC) or SPDT
Operating power.....As low as ½ watt
Time delays.....Up to 5 seconds
Operate on current differential as small as .05 amps
Operate on voltage differential as small as .3 volts





NOMINAL CHARACTERISTICS OF 609

Operating voltage.....6.4 volts
Operating time.....1. plus or minus .5 seconds
Release time.....1. plus or minus .5 seconds
Contact capacity.....1 amp at 30 volts
Contact arrangement.....SPDT

For additional data write:
Electroswitch Division, Tung-Sol Electric Inc., Newark 4, N. J.

Sales Offices: Atlanta, Ga.; Columbus, Ohio; Culver City, Calif.; Dallas, Tex.; Denver, Colo.; Detroit, Mich.; Irvington, N. J., Melrose Park, Ill.; Newark, N. J.; Philadelphia, Pa.; Seattle, Wash. Canada: Montreal, P. Q.

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How to keep informed on the "with what" part of your business

AT YOUR FINGER TIPS, issue after issue, is one of your richest veins of job information – advertising. You might call it the "with what" type – which dovetails the "how" of the editorial pages. Easy to read, talking your language, geared specifically to the betterment of your business, this is the kind of practical data which may well help you do a job quicker, better – save your company money.

Each advertiser is obviously doing his level best to give you helpful information. By showing, through the advertising pages, how his product or service can benefit *you* and *your* company, he is taking *his* most efficient way toward a sale.

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McGRAW-HILL PUBLICATIONS

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Practical Automation

JUST OUT! **Shows how to install and use plant automation for increased productivity,** lower operating costs, and improved safety and working conditions. Gives scores of examples of successful installations from plants of all sizes in various industries—demonstrates actual applications and methods. Covers automatic handling, processing, inspection, etc., in a way to help you plan ahead for successful automation. **By L. R. Bittel, M. G. Melden, and R. S. Rice, Factory Mgt. & Maint, 384 pp., illus., $7.50**

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Mechanism

A practical reference for designers and engineers. Analyzes various types of mechanisms and gives an authoritative source of mechanical movements. Discusses gears, cams, drives, linkages, controls, etc., and describes in detail mechanisms for digital and analog computers. Includes a valuable repertory of mechanisms—an illustrated collection of known mechanical movements. **By Joseph Stiles Beggs, Hughes Aircraft Co., and Consultant to U.S.A.F. 418 pp., 444 illus., $7.50**

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Helps engineers and techicians make money *inventing*. Shows many ways profitable inventions originated. Pointers on protecting, patenting, marketing inventions. By C. D. Tuska, RCA Patent Expert. 173 pp., illus., $3.75

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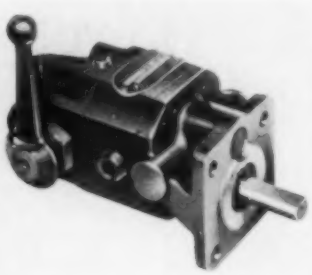
motors, such as those in air conditioning equipment. Ratings for the large base rectangular capacitors are 30, 35 and 40 microfarads at 440 v. Base dimensions are 4 9/16 in. by 2 27/32. Ratings for small base rectangulars are 20 microfarads, 440 v, and 30 and 35 microfarads, 370 v. Base dimensions are 2¼ in. by 2 15/16 in. Heights are up to eight in. General Electric Co., Schenectady 5, N. Y.

For more information—
Circle 82, inside back cover

FLUID POWER, CONTROL



Pump for Controlled Flow

This pump is provided with standard speed control handle, and is available in the following flow ranges: 0 to 1 gpm, 0 to 2 gpm, 0 to 4 gpm, 0 to 6 gpm. The 0 to 4 and 0 to 6 gpm flows are obtained by running at 3450 rpm with ½ in. and ¾ in. gear faces respectively. The suction part is ½ in. pipe tap, the metered flow is ½ in. pipe tap, and a ¼ in. pipe tap is provided for the return flow from the pipe top, the metered flow is ½ in. compensating stem.

Applications include controlled flow for lubricating systems and reciprocating type cylinders. John S. Barnes Corp., 181 Walnut St., Rockford, Ill.

For more information—
Circle 83, inside back cover

Neoprene Impeller Pump

This self-priming impeller model in ½ in. (iron pipe size) is designed to operate off a motor as small as 1/3 hp single-phase. Made of naval bronze throughout, with a stainless steel shaft, it handles all liquids that do not affect bronze or neoprene, at 7½ gpm,

(Continued on page 300)

PUT HEINZE IN YOUR DESIGNS

NEW! LOW-COST SINGLE COIL INDUCTION MOTOR

New in design, new in economy — the Heinze P Motor answers your need for a low-cost single coil 2 pole induction motor. It is available in various stacks and horsepower ratings from 1/300 to 1/50. Free speed is 3400 rpm; load speed 3000 rpm. Designed for 115 V, 60 cycle operation, the Heinze P Motor has broad application — in movie projectors, fans, gearmotors, advertising displays, pumps, toys, etc.

You have a wide choice of models from the comprehensive line of Heinze sub-fractional horsepower motors and blowers. Heinze Engineers are also ready to adapt standard models — or design a complete new motor or blower for your exact needs. Send us your product and specifications. We'll adapt a motor . . . at no obligation. Write for catalog.

HEINZE ELECTRIC COMPANY
685 Lawrence St., Lowell, Mass.

Sub-fractional Horsepower Motors and Blowers

A New and Better Chrome Carbide

CARMET Grade CA-815

FOR HOT EXTRUSION DIES

BETTER RESULTS

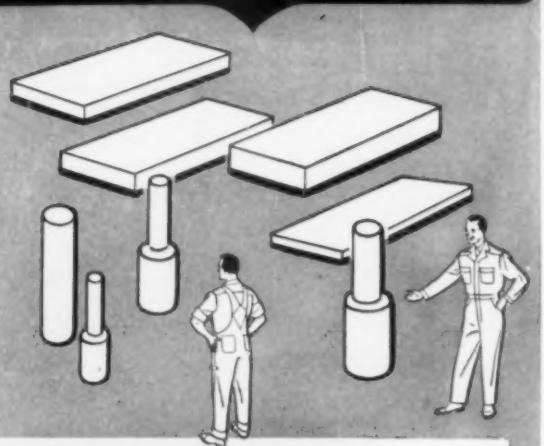
BETTER DIE LIFE
because of . . . High resistance to oxidation at elevated temperatures.

BETTER SIZE CONTROL
because of . . . Excellent wearability.

BETTER BAR FINISH
because of . . . High hot hardness.

LESS PICKUP AND GALLING
because of . . . Less affinity towards other metals.

FOR PRECISION GAGING



BETTER RESULTS

MORE ACCURATE GAGING
because of . . . Coefficient of expansion close to that of steel.

EXCELLENT SURFACE FINISH
because of . . . Low porosity.

EASY MAINTENANCE
because of . . . High resistance to corrosion.

LONGER GAGE LIFE
because of . . . Excellent wearability.

Write for the NEW
CARMET CATALOG

. . . Completely revised, the 16th Edition of the Carmet Catalog contains the latest information on all Carmet grades, and on Carmet blanks, tools, die sections, etc.; also gives details on special preforming and how to order special parts.

Address Dept. PE-91

Now for the first time a completely homogeneous chrome carbide is available . . . Carmet CA-815. Grade CA-815 is ideally suited for such operations as the two illustrated above . . . or for *any* application where resistance to corrosion as well as resistance to abrasion are a factor.

Carmet CA-815 is manufactured under controlled conditions. Die and gage makers are assured of complete dimensional accuracy and excellent surface conditions. Only minimum amounts of stock are left for finishing.

For further information on this and other Carmet carbide grades, call your Carmet Engineer . . . or write *Allegheny Ludlum Steel Corporation, Carmet Division, Detroit 20, Mich.*

WSW 6155

For ALL your CARBIDE needs, call

Allegheny Ludlum

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Polishing—Silencing—Washers—Gaskets—Liners—Channels—Weatherstrip—Packing—Filtration

1 FAN BEARING OILER. 2 WATER PUMP PACKING AND OILER. 3 GENERATOR BEARING SEALS. 4 GENERATOR AND STARTER LUBRICATING WICKS. 5 OIL FILTER. 6 BATTERY POSITIVE TERMINAL ANTI-CORROSION WASHER. 7 BRAKE BOLT OILER. 8 STEERING KNUCKLE TO TIE ROD DUST SEAL AND FLANGE JOINT SEAL. 9 STEERING ARM BEARING OILER. 10 FRONT WHEEL BEARING SEAL. 11 WHEEL BRAKE SHOE OILER. 12 CARBURETOR. 13 STEERING COLUMN GROMMET. 14 TRANSMISSION OIL SEAL WASHER (SEAL ASSEMBLY TRANSMISSION BEARING) 15 DRIVE SHAFT DUST SEAL. 16 TOE BOARD AND FLOOR BOARD LINER. 17 CLUTCH HOUSING PAN DUST SEAL. 18 BODY TO CHASSIS STRIPS. 19 WINDSHIELD WIPER PIVOT ARM MOUNTING. 20 WINDOW LIFT LUBRICATORS. 21 DOOR PANEL INSULATOR. 22 FLOOR BOARD PARTS. 23 UNIVERSAL OIL SEAL. 24 TURRET TOP INSULATION. 25 WINDOW RUN CHANNEL. 26 REAR AXLE DRIVE SHAFT SEAL. 27 AXLE PINION DRIVE BEARING SEAL. 28 UPHOLSTERY RISER STRIPS. 29 SPRING COVER LINING. 30 REAR PANEL WEATHERSTRIP. 31 FUEL TANK STRAP GASKET.

Write for S.A.E. Data Sheet No. 5, containing samples and full specifications of the standard S.A.E. Felts.

American Felt Company
TRADE MARK

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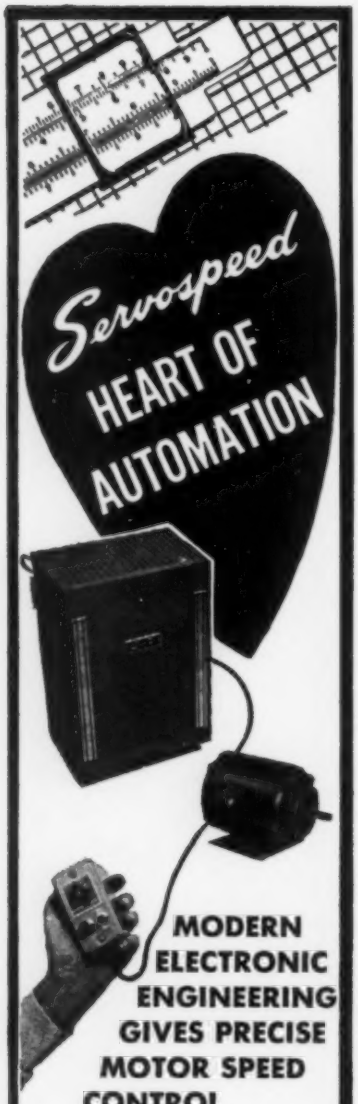
SALES OFFICES: New York, Boston, Chicago, Detroit, Cleveland, Rochester, Philadelphia, St. Louis, Atlanta, Greenville, S. C., Dallas, Boynton Beach, Fla., San Francisco, Los Angeles, Portland, San Diego, Seattle, Montreal.—PLANTS: Glenville, Conn.; Franklin, Mass.; Newburgh, N. Y.; Detroit, Mich.; Westerly, R. I.—ENGINEERING AND RESEARCH LABORATORIES: Glenville, Conn.

Some Additional Applications of felt: Clutch release link lever oiler • Window anti-squeak • Fuel tank support lining • Brake shoe anchor pin washer • Drag link dust cover • Intermediate steering arm bearing seal • Windshield wiper motor washer • Toe and floor board anti-squeak • Solenoid cover gasket • Heater core to housing filler • Spindle bolt grease retainer • Spindle bolt dust washers • Radius rod felt • Hydraulic lift spring seat • Door bumpers • Pedal pads and seals • Dash liners • Oil retainers • Polishing felts, for glass, metal and paint • Door liners • Ventilator valve seals • Weather seals • Hood lace filler • Moulding shim • Timing gear cover pad • Accelerator rod pad • Fuel tank shim • Propeller shaft spline oiler • Paint filter bags • Crankcase oil filter cap • Brake dirt seals • Defroster control valve seal • Hand brake cable clamp seal • Windshield division filler • Pinion bearing retainer packing • Horn wire locator felt • Oil sabre dust washer • Fender welt felt • Spring oiler felt • Spring bumpers • Gas filling protector pads • Rocker arm seals • Chafing strips for convertible tops • Upholstery padding • Radio selector pads • Thrust bearing inserts • Cab roof lining • Antenna weather seal • Blankets for protection during assembly and service • Factory table pads • Glycerine pads for windshield wipers •

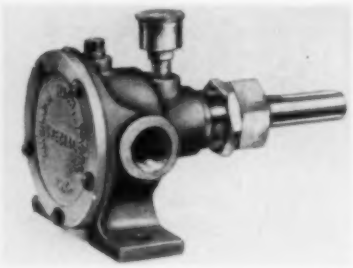
Entire Advertisement © 1957, American Felt Co.



MODERN ELECTRONIC ENGINEERING GIVES PRECISE MOTOR SPEED CONTROL

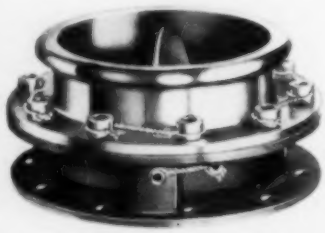
Modern industrial electronic engineering has been coordinated with electric motor design to provide a versatile means for obtaining the full possible advantage of speed control in DC motors while operated from the regular alternating current power line. Grid controlled "Thyratron" tubes are utilized for power controlled stepless variation to supply motor armature power. Patented feedback, or "Servo" circuits provide constant torque capability over wide speed ranges of as high as 60 to 1 in some models and a minimum of 20 to 1 in others.

Servospeed
DIV. of ELECTRO DEVICES, Inc.
4 Godwin Ave., Paterson, N. J.
ARmory 4-8989



10 psi at 1750 rpm. American Machine Products, Inc., 172 Centre St., New York 13, N. Y.

For more information—
Circle 84, inside back cover



Pneumatic Check Valve

A 3-in. pneumatic check valve has an operating temperature range of −65 F to 750 F for a typical 3-in. unit, total leakage does not exceed 0.1 lb per min for any combination of air temperature from 80 F to 750 F and air pressure from 5 psig to 210 psig. Barber-Colman Co., 1400 Rock St., Rockford, Ill.

For more information—
Circle 85, inside back cover

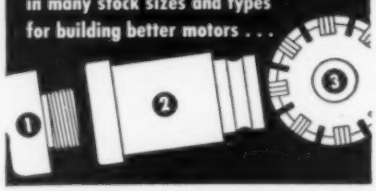
Precision Throttling Valve

Available with female pipe thread, female bronzed tube fitting and JIC threaded parts, this new valve is designed for use with oils, fuels and other liquids compatible with aluminum and steel in central hydraulic systems, missiles systems, aircraft and marine applications. The valves use standard O-ring seals; integral valve stem and poppet of hardened, ground and polished steel; with valve seat of hardened ball-bearing steel. They are available with 2 in., 1½ in. and 1¼ in. ported flanges adaptable to one basic body size; and 1 in., ¾, ½, ⅜ and ¼ in. ported flanges adaptable to another

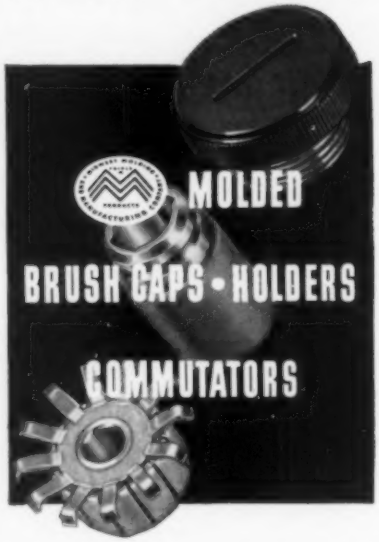
(Continued on page 304)

MIDWEST MOLDS ALL 3 FOR ELECTRIC MOTORS

Precision-molded components in many stock sizes and types for building better motors . . .



Design engineers and production planners use MMM as a dependable source for all 3 motor parts; available stock dies permit some variations in finish and materials.



CAPS available in 100 or more sizes; over 50 HOLDERS; over 40 COMMUTATORS. MMM can build dies and custom-mold to specifications for all electrical applications of plastics.

ONE SOURCE FOR ALL 3 MOTOR COMPONENTS

Investigate this experienced producer as your supply source of ready-for-assembly units for your motors. Ask for MMM Stock Size Charts, or send prints for quotation.

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...and cuts polishing costs in half!

CHASE DRY-ROLLED BRASS STRIP yields a higher polish at lower cost—that's what Luhr Jensen, Jr., maker of Luhr's famous fishing lures, found out.

"The final polish is far superior to anything we have been able to produce in the past," writes Mr. Jensen. "This gives a sparkle and fish-catching ability to our lures which is responsible for our continued increase in sales." And he adds: "The use of Chase Dry-Rolled Brass cuts our polishing costs approximately in half because the fishing lures can be polished in half the time, thus doubling our production with the same costs."

That's because Chase Dry-Rolled Strip is *pre-burnished*... needs little or no buffing. Yet it costs the same as regular strip! So whatever your product, chances are it may be improved—and money saved—if you check with Chase. Why not call us today?

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Atlanta Baltimore Boston Charlotte Chicago Cincinnati Cleveland Dallas Denver Detroit Grand Rapids Houston Indianapolis Kansas City, Mo. Los Angeles Milwaukee Minneapolis Newark New Orleans New York (Maspeth, L. I.) Philadelphia Pittsburgh Providence Rochester St. Louis San Francisco Seattle Waterbury

Know your timer types...

Grouping the multiplicity of timer types into four broad classes simplifies equipment designer's job:

INTERVAL TIMERS

The first—and simplest—group is that of the interval timers. These consist basically of a motor, an arm or cam, and a switch. To operate the timer, the user simply sets the mechanism manually to the desired time interval. This action transfers switch contacts that start the timer motor.

The motor drives the timer mechanism to the end of the timing cycle. At this point the switch returns to its original position and the motor shuts off.

A variety of dials, knobs, push-

INTERVAL TIMER of advanced design, the new Cramer Type 241 features large easy-to-read dial, pushbutton start, automatic and immediate reset and repeat accuracy of ± ¼ of 1% of full scale. Bulletin PB-241.

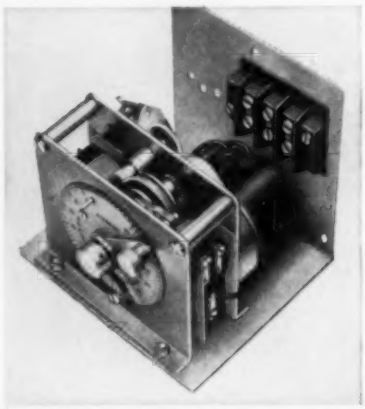
button start, automatic reset features, special housings and additional load switches may be used, but the basic operation is the same. Interval timers are used in applications that require frequent changes in setting—like photographic exposure timing.

TIME DELAY RELAYS

The time delay relay represents the second large group of timing devices. These units provide accurately timed delays between the closing of an external remote switch and the transfer of a load switch. At the end of each cycle, the motor shuts off automatically, and the standard device remains in this "timed out" condition until the clutch is released allowing the timer to reset. Other variations reset automatically at the end of a cycle. Models are available to either reset on power failure or suspend operation until the circuit is restored.

Special housings, additional switches, various clutching mechanisms, and a wide selection of wiring arrangements make the time delay relay an extremely versatile device.

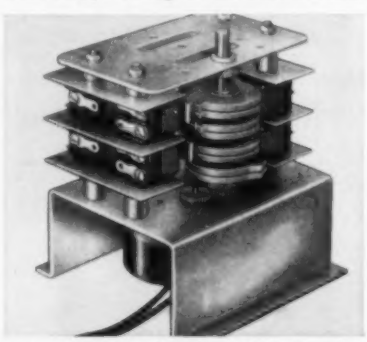
A typical application is for regulating processes such as heat treating where the timer controls the amount of time required to produce the desired change in the metal.



TIME DELAY RELAYS—like the Cramer Type 440A above—are rugged, dependable and accurate devices to control from 1 to 5 load circuits. For flush, surface or panel mounting. Bulletins PB-310 and PB-311.

CYCLING TIMERS

In the third category are found the cycling timers. Fundamentally these units are made up of the driving motor, a cam (or arm) which is revolved continually by the motor, and a switch operated by the cam. The cycling timer produces switch transfer repeatedly, according to the cam cuts, as long as the motor runs.



CYCLING TIMERS—like this Cramer Type 520 come in 1 to 8 poles. Normally factory preset for highest accuracy. Operating speeds 1 rev./6 sec. to 1 rev./day. Bulletin PB-510A.

Variations of the cycle timer include changing the motor speed, cutting cams in an almost infinite number of combinations, and adding switches. The cam setting may be fixed or adjustable. Special housings are available. Cycle timers are used to control a program or sequence of events as in a signaling system.

TIME TOTALIZERS

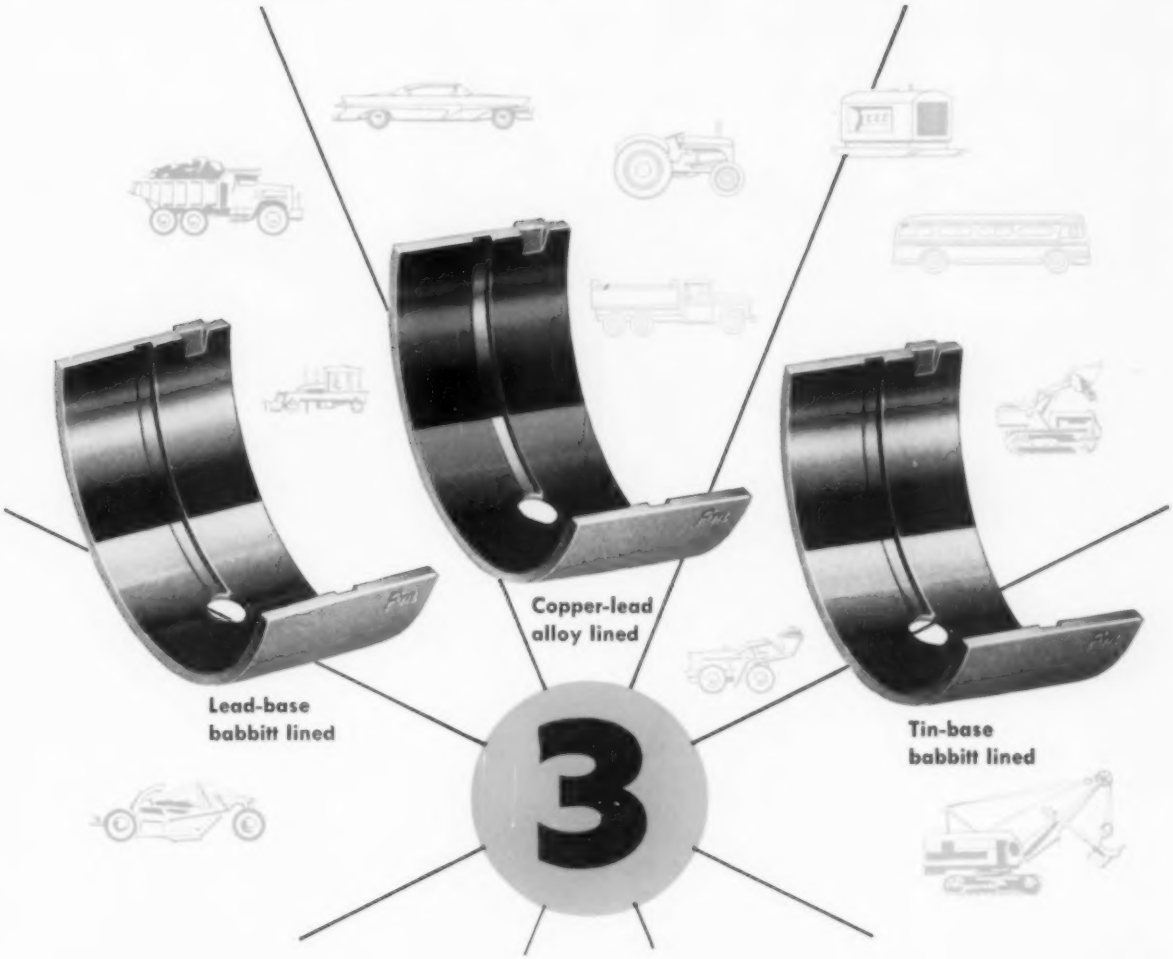
Time totalizers, or elapsed time indicators, range in complexity from a simple motor-driven counter to the precision time totalizer used in scientific research. The former, usually used as a running time meter, counts discrete time *units* from tenths of a second to hours. The more elaborate time totalizer is actually an electrical stop clock capable of measuring time intervals to an accuracy of ± 0.01 second. Running time meters are used to record the operating or down time of industrial machines. They are offered in many models—with or without reset, in portable or die-cast enclosures, etc. Time totalizers are commonly applied in test equipment for industrial and military laboratories.

NEW TIME TOTALIZER of laboratory quality. This new Cramer Type 691 features instantaneous electrical reset (within .1 second). It is human-engineered by Raymond Loewy for fast exact readings, accuracy to ± .01 second. Reset can be either by local push button or controlled remotely. Bulletin PB-691.

LEARN MORE about these four basic timer types from Cramer's complete line. Just ask us to send you our bulletins on the types that interest you. Nearly 100 varieties are *stocked* for immediate shipment. Cramer Controls Corporation, Box 7, Centerbrook, Connecticut. (Formerly R.W. Cramer Co.)

TALK IT OVER WITH

CRAMER CONTROLS
CORPORATION



bearings that meet the widest range of engine applications

Across the broad range of engines which impose light or medium loads on the bearings, tin-base and lead-base babbitt-lined bearings are the economical, dependable "work horses". For the newer engines imposing heavy loads, bearings lined with copper-lead alloy are the answer. Using our patented, low oxide copper-lead powder alloy as the heart of the lining, steel-backed copper-lead bearings produce new performance standards in heavy-duty operation. For complete information address:

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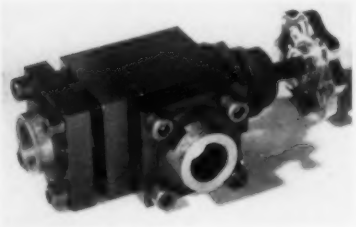
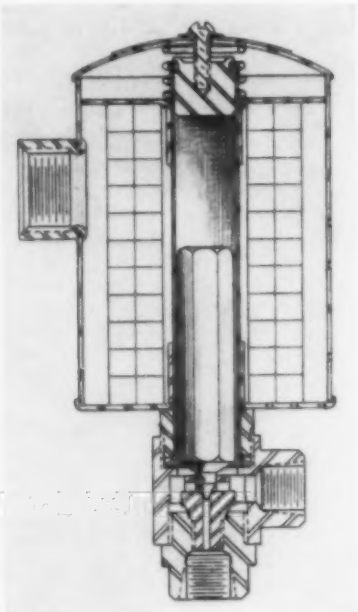


basic body size. Greer Hydraulics, Inc., New York International Airport, Jamaica 30, N. Y.

For more information—
Circle 86, inside back cover



Solenoid Valves

These stainless steel valves for corrosive gases and liquids are available in $\frac{1}{8}$ in., $\frac{1}{4}$ in., and $\frac{3}{8}$ in. pipe sizes with ports from 1/16 to $\frac{1}{4}$ in. These valves have type 316 stainless steel and Teflon in contact with the medium flowing through the valve. J. D. Gould Co., 4707 Massachusetts Ave., Indianapolis 18, Ind.

For more information—
Circle 87, inside back cover

Pressure Control Valves

A diaphragm-operated high pressure control valve designed for automated control and suitable for use in oil, air, steam, and hot or cold water

(Continued on page 308)

"But I am constant as the northern star"

—Julius Caesar Act III Sc. 1

You know what to expect from CLARE Mercury-Wetted-Contact Relays—always. Their performance is CONSTANT.

Constant contact stability—No contact chatter—none at all.

Constant contact resistance—Repetitive measurements on individual relay contacts are constant to a few milliohms. Resistance of single contacts, including resistance of internal wiring between base terminals, ranges between 25 and 40 milliohms. Contact deterioriation cannot occur in this relay.

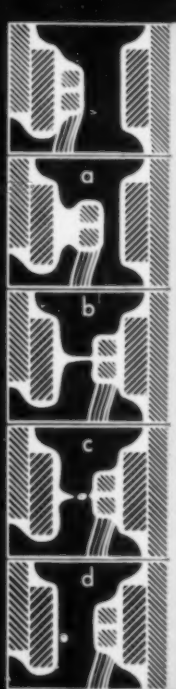
Constant operate time—Varies by only about 0.1 millisecond under constant drive conditions.

Constant pull-in current—Repetitive operating precision of given relay is within 1% of its minimum operating current. This precision is substantially independent of number of operations or ambient temperature.

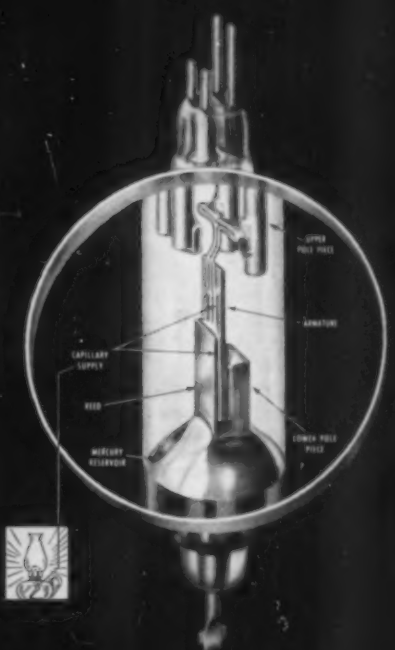
Constant adjustment—Requires no maintenance whatever. No possibility of change in adjustment. This remains true even after thousands of millions of operations.

If you have a job for which none but the best relay is good enough, it can cost you much more to settle for less than this CLARE RELAY. For complete information contact your nearest Clare representative or address C. P. Clare & Co., 3101 Pratt Blvd., Chicago 45, Illinois. In Canada: C. P. Clare & Co., 659 Bayview Avenue, Toronto 17. Cable address: CLARELAY.

Send for CLARE Sales Engineering Bulletins Nos. 120 and 122



Drawings (left) from high-speed photographs show the cycle. (a) Filament of mercury forms between the contacts as they separate. (b) This becomes narrower in cross section and (c) finally parts at two points, allowing globuls of mercury to fall out. Mercury flows up the capillary path, replaces amount lost, restores the equilibrium. (d) The momentary bridging of the parting contacts—and the extremely fast break that ends it—minimizes the arc and adds greatly to contact load capacity. Contact closure between the two liquid surfaces bridges mechanical bounce and prevents any chatter from appearing in the electrical circuit.



Contacts of CLARE Mercury-Wetted-Contact Relays are constantly renewed. By capillary action, like that of a lamp wick, a new film of mercury coats each contact with every make and break.

CLARE RELAYS

FIRST in the industrial field

(Advertisement)

SPECIAL REPORTS ON FINISHING NON-FERROUS METALS

NUMBER I—Decorative, Corrosion-Resistant Finishing with Iridite

Chromate conversion coatings are well known and accepted throughout industry as an economical means of providing corrosion protection, a decorative finish or a good paint base for non-ferrous metals. However, continued developments are so rapid and widespread that many manufacturers may not be completely aware of the breadth of application of this type of finish. Hence, this digest of current information; to bring you up to date on the many ways in which you can combine salable appearance with durability in one finish at a competitive price advantage. Report II on paint base, corrosion-resistant finishes and Report III on chemically polished, corrosion-resistant finishes are available on request.

First, as a basis for this discussion, a "decorative" finish is considered as any chromate film that is used as a final finish in itself. It may be truly decorative in that its sole purpose is to enhance the beauty of the product. For example, a bright chrome-like finish or a pleasing bronze appearance are among the many effects that can be obtained. It may be functionally decorative in that it reduces reflectivity for camouflage purposes or provides a means of color-coding parts. But, in all cases, the Iridite films protect the metal against corrosive attack.

Iridite finishes are now available for all commercial forms of the more commonly used non-ferrous metals, including zinc, cadmium, aluminum, magnesium, silver, copper, brass and bronze. These films can produce a wide variety of pleasing appearances. The basic colors of the Iridite coatings are grouped below by metals.

ZINC and CADMIUM: Metallic bright, light iridescent, iridescent yellow, bronze, olive drab.

COPPER, BRASS, BRONZE: Metallic bright, yellow.

ALUMINUM ALLOYS: Clear, iridescent yellow, brown.

MAGNESIUM ALLOYS: Light brown, dark brown, black.

SILVER: Metallic bright.

In addition, many films can be modified by bleaching or by dyeing. Among the dye colors available are various shades of red, yellow, green, blue or black.

Depending upon the metal and the Iridite used, corrosion resistance of clear and bright films ranges from mild passivity to as high as 500 hours in salt-spray; on heavier dark films, salt-spray resistance ranges from approximately 100 to 1000 hours.

It is this combination of decorative and corrosion resistant properties that accounts for the widening use of Iridite finishes. For example, Iridites #4-73 and #4-75 (Cast-Zinc-Brite) make possible for the first time, a combination of lustrous chemical polishing of the as-cast surface of zinc die castings and good resistance to corrosion. Further, in many cases, sizeable savings in the cost of buffing and electroplating are realized.

WHAT IS IRIDITE®

Briefly, Iridite is the tradename for a specialized line of chromate conversion finishes. They are generally applied by dip, some by brush or spray, at or near room temperature, with automatic equipment or manual finishing facilities. During application, a chemical reaction occurs that produces a thin (.00002" max.) gel-like, complex chromate film of a non-porous nature on the surface of the metal. This film is an integral part of the metal itself, thus cannot flake, chip or peel. No special equipment, exhaust systems or specially trained personnel are required.

On many steel parts, a simple system of zinc or cadmium plate and bright Iridite is used instead of more costly electroplated finishes to provide a bright, decorative and protective finish with tremendous savings in material, equipment and labor.

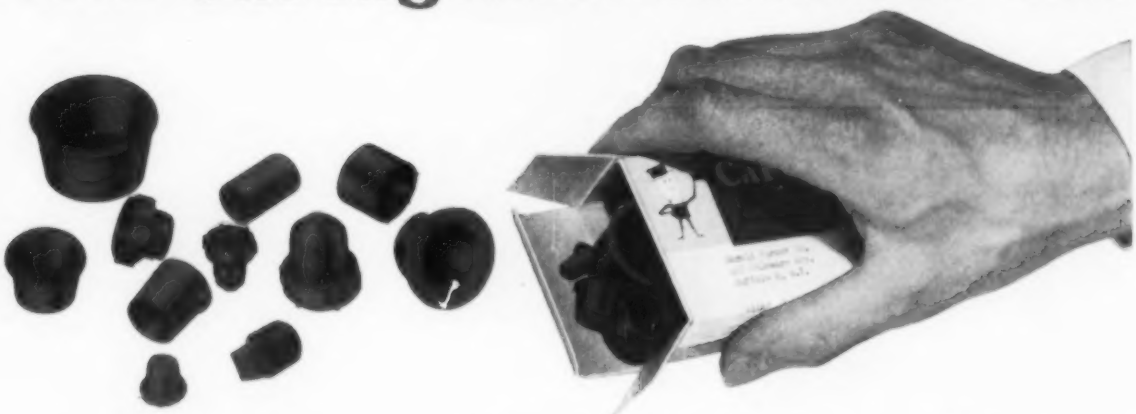
In finishing aluminum, where corrosion resistance or paint adherence is the prime consideration, the aircraft industry has all but abandoned the anodizing process in favor of recently developed chromate conversion coatings, among them Iridite #14 and #14-2 (Al-Coat). These formulations and their method of application can be varied to retain the original metallic appearance while providing acceptable corrosion resistance, or to produce a fully colored brown finish that offers exceptional corrosion protection. Again, time and manpower savings are astounding—one company saved at least $15,000 a year on maintenance of racks alone and another $40,000 on materials and labor in only nine months. In addition, of course, hundreds of thousands of dollars are saved by eliminating the need for expenditures for generators, heating equipment and racks.

Iridites are widely approved under both Armed Services and industrial specifications because of performance, low cost and savings of materials and equipment.

In planning or designing, you should consider the many other characteristics of Iridite finishes which may enter into the specific problem. In addition to having decorative and protective functions, these chromate coatings form an excellent base for organic finishes and bonding compounds. They have low electrical resistance. Some can be soldered and welded. The Iridite film itself does not affect the dimensional stability of close tolerance parts.

You can see then, that with the many factors to be considered, selection of the Iridite best suited to your product requires the services of a specialist. That's why Allied maintains a staff of competent Field Engineers—to help you select the Iridite to make your installation most efficient in improving the quality of your product. You'll find your Allied Field Engineer listed under "Plating Supplies" in your classified telephone book. Or, write direct and tell us your problem. Complete literature and data, as well as sample part processing, is available. Allied Research Products, Inc., 4004-06 E. Monument Street, Baltimore 5, Maryland.

a free CaPlug assortment like this

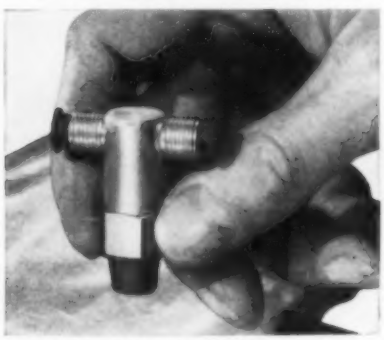


will give you dozens of ideas for protecting products like these

JUST PUSH THEM IN . . . OR PUSH THEM ON
Tapered (non-threaded) CaPlugs can be used as caps or plugs, inside or outside of threaded or plain fittings. Threaded styles are knurled to screw on or off with ease. Made of tough, flexible Polyethylene, CaPlugs are unaffected by most chemicals, acids and solvents . . . will not collapse, chip, break or shred.

"KID GLOVE" PROTECTION WITH A DUAL PURPOSE
Here's how Resistoflex Corp. makes two-fold use of CaPlugs "to protect critical threads and machined surfaces and to keep the interiors of hose assemblies clean and dust-free." Says Resistoflex, "CaPlugs prove most effective for both functions as well as being particularly easy to install."

COUNTLESS USES BY THOUSANDS OF USERS
Bell Aircraft Corp. applies both threaded and non-threaded CaPlugs to a wide variety of parts (such as these) in the manufacture of guided missiles, electronic components, rocket engines and servomechanisms. Throughout industry, many a company has found that CaPlugs provide the perfect answer to practically every closure need.



MAKES A PRODUCT LOOK ITS "SUNDAY BEST"
On this Alemite Accumatic Valve, colorful red CaPlugs add snappy eye appeal and indicate care of manufacture. Says Stewart-Warner Corp., "CaPlugs help impress the customer with the steps that have been taken to protect the equipment and convince him of the continuing need for protecting lubricants against contamination."

THERE'S A CAPLUG THAT WILL DO THE TRICK *You name it! With numerous styles (threaded and non-threaded) stocked in over 500 sizes, "off-the-shelf" deliveries can be made from a 35,000,000 inventory to answer your immediate requirements promptly. You get closures that are right for your jobs . . . right on time.*

GET A FREE BOX OF CAPLUGS, DETAILS AND PRICES BY MAILING THIS COUPON

CAPLUGS DIVISION, PROTECTIVE CLOSURES CO., INC.
2207 Elmwood Ave., Buffalo 23, N. Y.

RUSH a free assortment of CaPlugs, literature and prices to us, without obligation.

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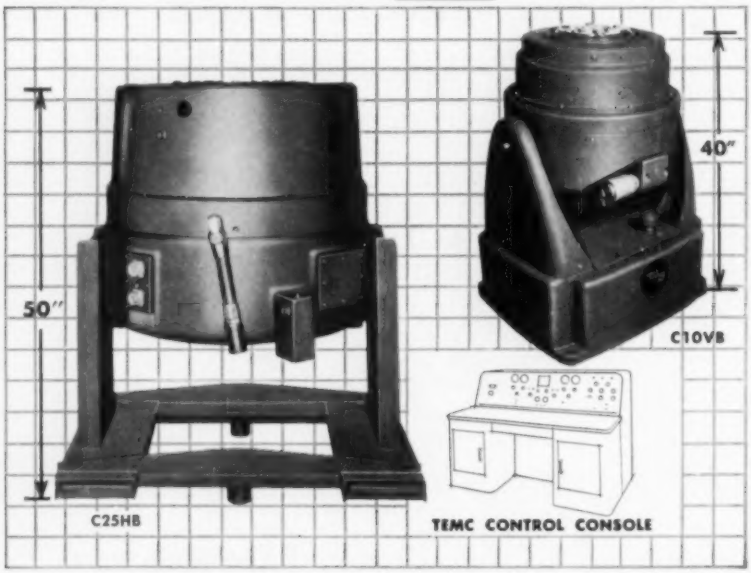


Vibration Testing cuts product development time

Testing components and structures with electrodynamic vibration exciter systems cuts research and development time in aircraft and missile systems. Often within hours, or minutes, the effect of service vibration can be pinpointed.

MB has perfected shaker systems that permit testing to all required specifications, enable engineers to speed product development from blueprint to prototype to production.

COMPLEX MOTION TESTING

Several MB Exciter Systems reproduce complex and random motions. They can subject products to the actual service vibration. The Model C10VB Shaker shown offers the widest frequency range for its force. Model C25HB provides higher forces for higher "g."

ENVIRONMENTAL TESTING

Both the above shaker systems can be used with environmental chambers . . . for "high altitude" and high or low temperature vibration testing. Oil cooled, they don't affect chamber vacuum.

SPECIFICATIONS

MB C10VB System provides . . .
10 "g" on table loads to 145 lbs.
20 "g" on table loads to 57.5 lbs.

Force output:	Band width:
1750 lbs. Sine	5-5000 cps
1050 lbs. RMS	15-2000 cps
3150 lbs. Peak	15-2000 cps

MB C25HB System provides . . .
10 "g" on table loads to 422 lbs.
20 "g" on table loads to 172 lbs.

Force output:	Band width:
5000 lbs. Sine	5-2000 cps
3500 lbs. RMS	15-2000 cps
10,500 lbs. Peak	15-2000 cps

In meeting your requirements, MB offers you advanced designs . . . plus quality construction of shaker, amplifier and control system . . . plus an experienced field service organization.

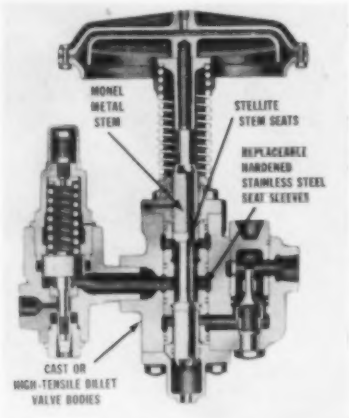
MB manufacturing company

A DIVISION OF TEXTRON, INC.

1075 State Street, New Haven 11, Connecticut

HEADQUARTERS FOR PRODUCTS TO ISOLATE . . . EXCITE . . . AND MEASURE VIBRATION

service at pressures up to 6000 psi offers resistance to corrosion by a Monel valve stem, hardened stainless steel seat sleeve and valve bodies of cast Navy M bronze or high-tensile alloy billet bronze. Stellite seats are electro-bonded to the Monel stem and stainless


MONEL METAL STEM
STELLITE STEM SEATS
REPLACEABLE HARDENED STAINLESS STEEL SEAT SLEEVES
CAST OR HIGH-TENSILE BILLET VALVE BODIES

steel seat sleeves are easily replaceable. Valves come in sizes ¼ to 3 in. NPT Sinclair-Collins Valve Co., 454 Morgan Ave., Akron 11, Ohio.

For more information—
Circle 88, inside back cover

Magnetically Operated Pilot Valve

This three-way, normally open magnetically operated miniature pilot valve weighs 0.375 lb. and is rated for up to 4500 psi service. A hermetically sealed solenoid, which operates within a 14 to 32 v range controls the flow through what is equivalent to a

(Continued on page 311)

"Best yet...
for Heavy Duty
HOLE PUNCHING
up to ¼" steel"

"Our CJ Tooling is fast and clean for heavy duty work on sheets, and we're also getting big profit from punching holes in channels, angles etc. That's a tough proposition for the average shop . . . but not for us! With our WALES equipment we cut vees and corner notches at the same time. It really boosts our production."

WALES CJ Units punch unlimited straight line, staggered and scattered patterns . . . round or shaped holes. Die retention design features rapid die change WITHOUT REMOVING UNIT from set-up . . . provides controlled slug ejection. Time saving and money saving. Same units may be used over and over again in other patterns.

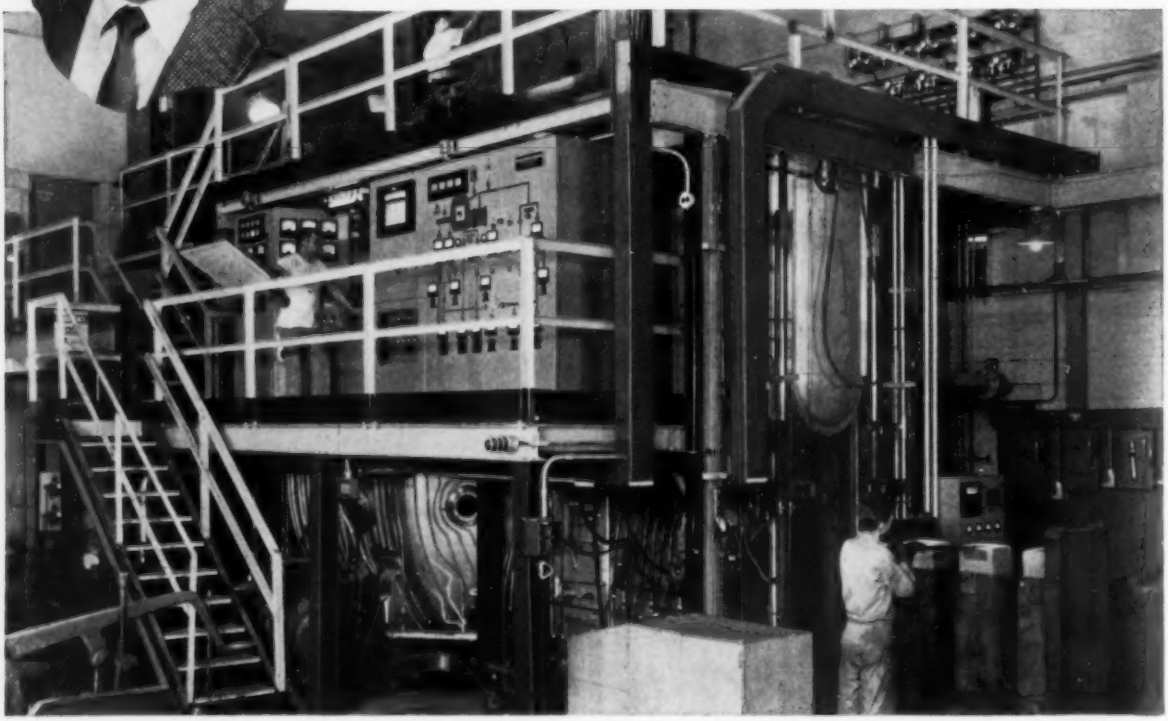
SEND FOR
BULLETIN NO. 22F
Shows actual job work and complete data of CJ sizes.

WALES MOBILE FIELD UNITS
Will demonstrate CJ and other tooling right at your door. Ask for details.

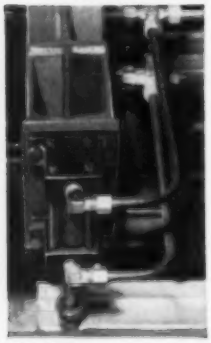
WALES Strippit COMPANY
A UNIT OF HOUDAILLE INDUSTRIES, INC.
AKRON, NEW YORK
WALES-STRIPPIT OF CALIF., SOUTH GATE, CALIF.
WALES-STRIPPIT OF CANADA LTD., HAMILTON, ONT.
"...the Wales-Way is the PLUS-PROFIT way"

"Our experience demonstrated that hydraulic line rupture can occur in proximity to molten metal without fire when Cellulubes are used . . ."

Mr. Arthur E. Franks of Vacuum Metals Corporation, Syracuse, N.Y.



". . . this is why fire-resistant Celanese Cellulube hydraulic fluid is in use in the world's largest vacuum furnace at Vacuum Metals Corporation."



Hydraulic Controls on the world's largest vacuum furnace

In designing the hydraulic controls for its 2500-pound vacuum melting furnace, Vacuum Metals selected Cellulube hydraulic fluid because of its fire resistance and low vapor pressure characteristics. Laboratory tests and operating experience demonstrated that the unique combination of Cellulubes' properties made it the ideal material for this application.

These findings are typical of Cellulubes' performance during continuous operation under critical conditions. As hydraulic fluids, Cellulubes reduce the dangers of fires and explosions caused by line breaks or other equipment failures. As air cylinder lubricants, Cellulubes prevent the formation of excessive carbon deposits—the main source of compressor fires and explosions.

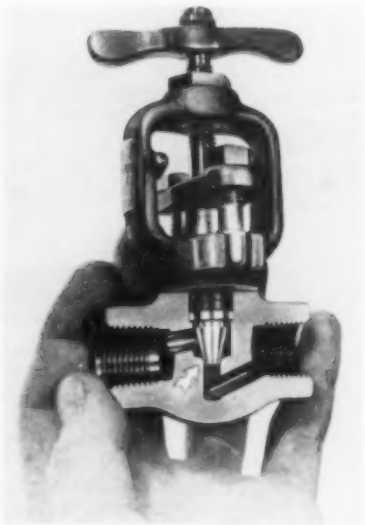
Available in 6 controlled viscosities, Cellulubes can be supplied to meet exacting requirements in the replacement of flammable fluids presently in use. Play it safe, write for complete data and technical assistance. Celanese Corporation of America, Chemical Division, Dept. 547-G, 180 Madison Ave., N. Y. 16.

Celanese®
Cellulube®

Celanese
CHEMICALS

sharp edge orifice diameter of 0.030 in. The ambient temperature range is −100 F to 250 F; fluid temperature range is −65 F to 250 F. Marotta Valve Corp. 330-40 Boonton Ave., Boonton, N. J.

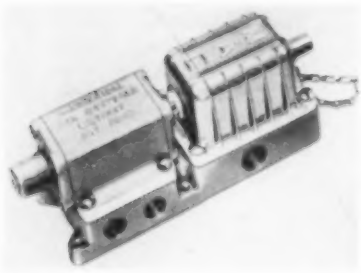
For more information—
Circle 89, inside back cover



Instrument Valve

This valve has a seat insert of chrome-cobalt-tungsten alloy (arrow). Rated at 2500 lb at 850 F, the valves have drop forged steel bodies and yokes and swing-bolted glands for easy repacking. Edward Valves, Inc., E. Chicago, Ind.

For more information—
Circle 90, inside back cover



Air Valve

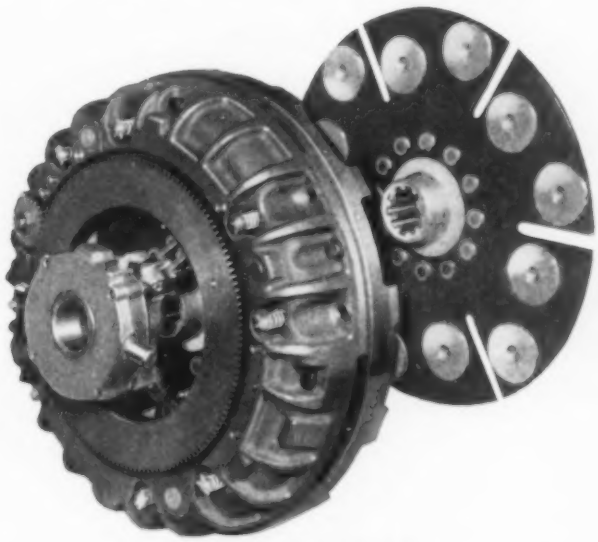
Designed to meet every JIC valve standard, this valve features an independent body and solenoid; each can be removed separately from the base without disturbing the other.

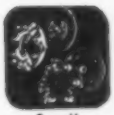
The unit also has an integral con-

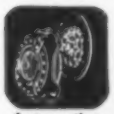
(Continued on page 314)

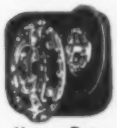
ROCKFORD

OVER-CENTER CLUTCHES



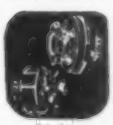

Small Spring Loaded


Automotive Spring Loaded


Heavy Duty Spring Loaded

Oil or Dry Multiple Disc

Heavy Duty Over Center


Light Over Center

Power Take-Offs

Speed Reducers

PROVIDE

HIGH TORQUE

EASY OPERATION
HIGH TORQUE
POSITIVE ENGAGEMENT
LARGE DRIVING AREA
SMOOTH RUNNING
INFREQUENT ADJUSTMENT
MINIMUM INERTIA

Equally spaced, hardened and ground roller cams, bearing upon hard steel insets, exert heavy pressure evenly over the entire ROCKFORD Over-Center CLUTCH face—producing unusually high torque, for the clutch size and weight. The anti-friction roller cams—an exclusive feature—make over-center clutch operation extremely easy, exert heavy pressure symmetrically and contribute substantially to long life, reliable operation without adjustment.

SEND FOR THIS HANDY BULLETIN

Shows typical installations of ROCKFORD CLUTCHES and POWER TAKE-OFFS. Contains diagrams of unique applications. Furnishes capacity tables, dimensions and complete specifications.

ROCKFORD Clutch Division BORG-WARNER

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ENGINEERING B-W PRODUCTION

CLUTCHES

Sylvania knows both sides of this composite wire story

WHICH KIND OF WIRE will do your job better . . . plated? or clad? In Sylvania's case histories, one usually comes out on top, pricewise, performancewise . . . or both.

And perhaps Sylvania can help you decide which it is for you. As a manufacturer of both types, we'll give you our best and objective opinion of whether you could better be using a plated wire where you're now using clad . . . or clad where you're now using plated.

No matter what wire properties your application calls for, it will help you to know that Sylvania is one of the nation's top custom platers of wire. Plating ranges from flash to 20% by weight in a wide range of materials in sizes from .250″ to .002″. Or, your custom wire can be clad in just about any combination of cold-drawn materials.

Alloy wires too, are available on both a custom and standard basis, as well as custom wire welds, and plated metal strip. Sylvania Parts Division is your source for metal stamping, plastic molding and special components as well. Write for complete information.

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Sylvania Electric Products Inc., Parts Division, Warren, Pennsylvania

LIGHTING • RADIO • TELEVISION • ELECTRONICS • ATOMIC ENERGY

SPECIAL WIRE | METAL STAMPINGS | MOLDED PLASTIC | ELECTRONIC COMPONENTS

4-way service from one source

NEW! CLARK Type "AL" AUTOMATION CAM LIMIT SWITCH

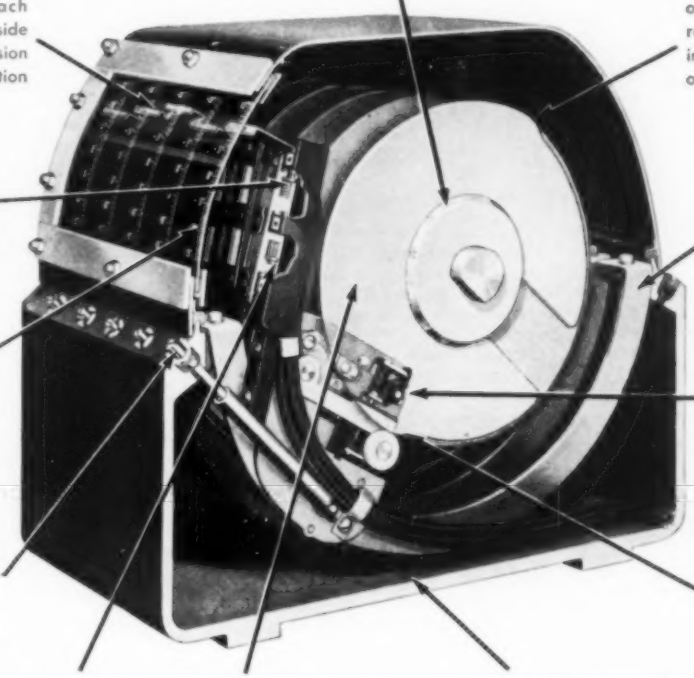
— ADJUSTABLE IN MOTION —

GREATER SAFETY! GREATER FLEXIBILITY! GREATER PRECISION! EASIER MAINTENANCE!

PRECISION—Cams can be loosened and reset without removing them from shaft. Graduations facilitate making precise settings.

PRECISION—Graduated scales for adjustment of each switch unit are printed on inside of clear plastic window. Provision is made for circuit identification visible through window.

SAFETY—Switch unit is actuated only when roller is riding on raised segment of cam. Jogging in reverse does not alter sequence of operations.



FLEXIBILITY—An additional isolated contact—easily convertible in the field—is available for each switch unit, to permit control of two circuits from a single unit.

FLEXIBILITY—Rear-mounted switch units can be added to permit micro-adjustment of both make and break of a single circuit operated by a single cam.

MAINTENANCE—All contacts clearly visible through plastic window. Inspection may be made without removing switch cover.

PRECISION—Snap-action, latching type switch units make possible smooth performance, being operated by constant acceleration cams eliminating "bumping".

PRECISION—Position of switch unit can be adjusted to micro-accuracy over a 30° range from outside housing *while machine is in motion.*

SAFETY—Cams force contacts open and hold them open—assuring postive break.

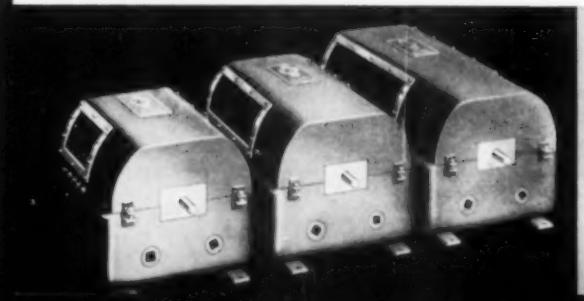
SAFETY
Heavy-duty 15 ampere industrial-control type contacts will not jar open with severe vibration.

PRECISION
Large (7-in.) twin-disc adjustable butterfly cams operate each circuit. Wide variety of cam equipment available to cover range of contact operations from 15° to 345°.

MAINTENANCE—Enclosure with cast aluminum base and welded steel cover meets NEMA 4 (watertight) and NEMA 12 (automotive and J.I.C.) standards. Oil resistant rubber gasketing and packing under pressure completely seal enclosure.

3 basic sizes: 5 cam, 9 cam and 12 cam. The 12-cam size can be modified to accommodate up to 16 cams. With double-sided switch arrangements, each size can provide additional switch units up to one less than the number of cams.

These new CLARK Type "AL" Cam Limit Switches meet the rugged requirements of large presses, and have broad application on many other machines where accurate and dependable sequence operation of multiple circuits is required. They are ideal for use where it is advantageous to make precision adjustments while machines are in motion, and are particularly suitable for many applications in the field of Automation.



For more information, write for Bulletin 102-AL

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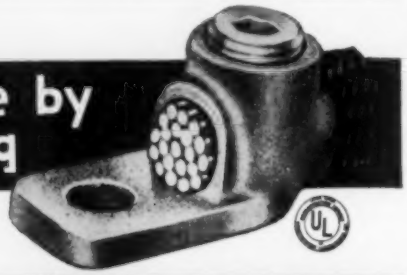


PENNLUG

The *Economy* lug with *Quality* improvements:

- **Insulation butts flush.**
- **Serrations give better grip.**
- **More contact area.**

Write for Sample

7 sizes take 14 sol. to 1000 MCM. NEMA drilling. 45° or 90° tongue. Also available, multiple grip or hex-head screws.

Price is as attractive as the lug. Write for samples of sizes you use. PENN-UNION ELECTRIC CORP., Erie, Pennsylvania.

Sold by Leading Wholesalers

PENN-UNION

duit box to make it more compact and a solenoid with shock-resistant mountings. It is available in ⅜ in. single-solenoid, double-solenoid and three-way models. Mechanical Air Controls, 10030 Capital, Detroit 37, Mich.

For more information—
Circle 91, inside back cover

Ball Valves

A series of plastic valves provide shut-off in both directions. They are available with female threaded ends in ½, ¾, 1, 1¼, 2 and 3 in. nominal pipe sizes. Rated at 150 psi, allowable temperature is over 200 F in continuous duty. Chemtrol Corp., 1417 W. El Segundo Blvd., Compton, Calif.

For more information—
Circle 92, inside back cover

ENGINEERING MATERIALS

Erasing Machine

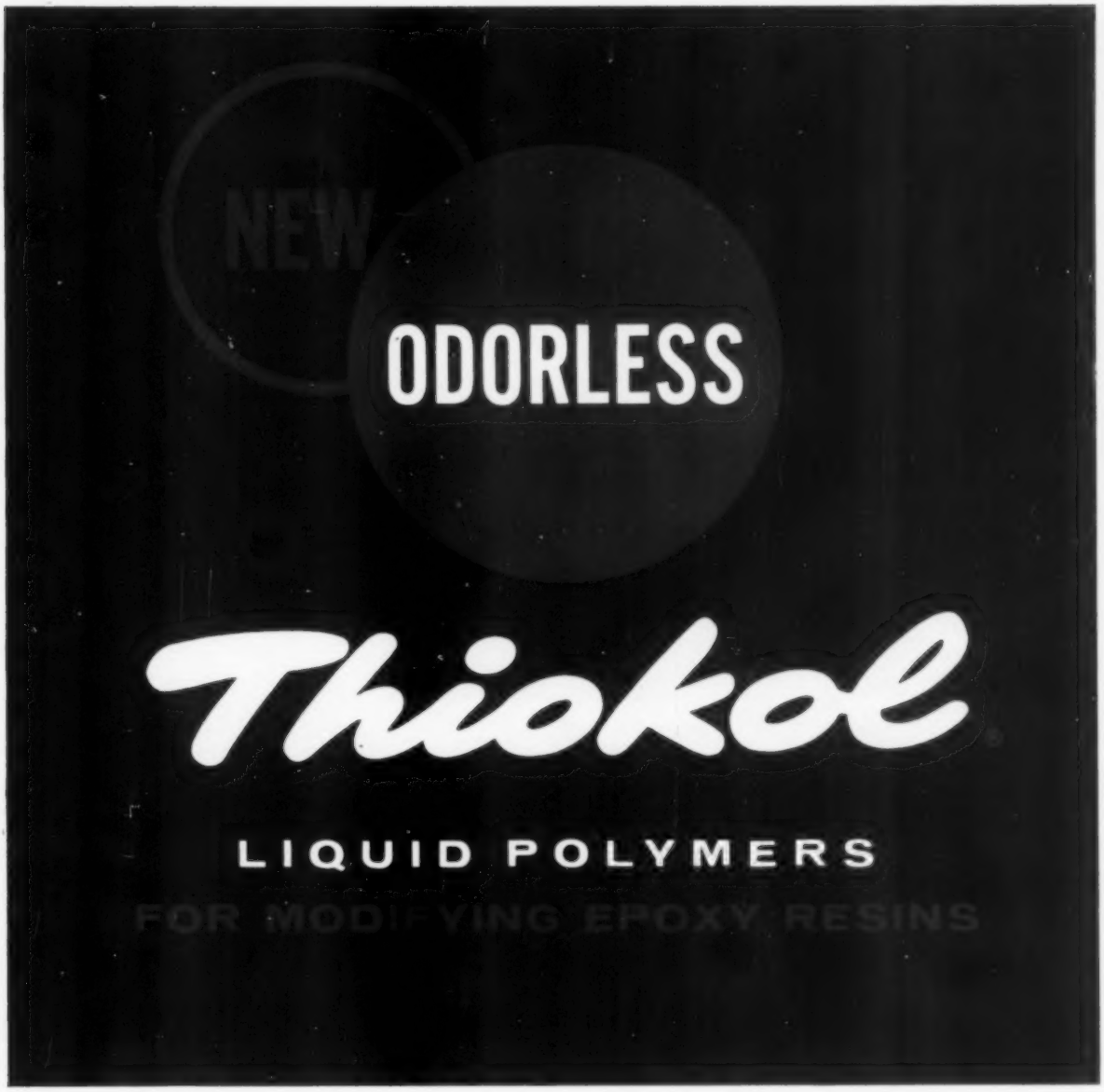
Called the "Sovereign", an electric erasing machine operates cool under heavy work conditions, has minimum torque and automatic stall control to protect drawings against damage from heavy pressure. Frederick Post Co., 3650 N. Avondale Ave., Chicago 18, Ill.

For more information—
Circle 93, inside back cover

Differential Transformer Kit

Kit consists of seven complete differential transformers having a linear range from ±0.01 to ±2.5 in., a flexure plate and clamp for positioning coils, and a demodulator which con-

(Continued on page 316)



The new, odorless THIOKOL liquid polymers developed especially for modifying epoxy resins are suitable for a wide range of applications at an overall lower cost.

Designated EM-206 and EM-207, these liquid polymers give epoxy resins greater flexibility, resilience and impact strength, for use in plastic tooling, castings, adhesives and other applications. Full cures can generally be obtained at room temperature. The new THIOKOL liquid polymers/epoxy resin combinations offer improved workability due to low viscosity, increased pot life, lower temperature rise due to exothermic reactions and better temperature cycling.

For additional information about these new THIOKOL liquid polymers write:
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780 North Clinton Avenue, Trenton 7, N. J.
In Canada, Naugatuck Chemicals Division,
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Specially engineered sections saved high planing and machining labor costs. West Virginia engineering consultants helped develop a special rolled section produced to the rigid, high specifications required for any Caterpillar-built machine.

West Virginia Special Sections have saved time and money and assured ultimate strength in the products of many major companies. A West Virginia engineer may be able to help you with your production problems.

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CONNORS STEEL DIVISION
H. K. PORTER COMPANY, INC.

verts a-c output of the differential transformer to d-c voltage. Automatic Temperature Control Co., 5200 Pulaski, Ave., Philadelphia 44, Pa.

For more information—
Circle 94, inside back cover

Transparent Tape

Useful in making blueprints and whiteprints, this self-sticking tape is printed in red and will reproduce photographically. Unlike cellophane, this polyester film is a dimensionally stable, high strength, non-brittle tape. It is offered in nine patterns, all available in six standard widths from 1/32 in. to 1 in. American Chart Service, Inc., 101-103 Dover St., Somerville 44, Mass.

For more information—
Circle 95, inside back cover

Wall Charts for Isometric and Dimetric Drafting Guidance

A set of three wall charts in color and measuring 30 x 40 in. demonstrates basic relations between orthographic and axonometric projection, and the laws governing the required angles, scales and ellipse shapes. An explanatory leaflet comes with the charts. John R. Cassell Co., Inc., 110 W. 42 St., New York 36, N. Y.

For more information—
Circle 96, inside back cover

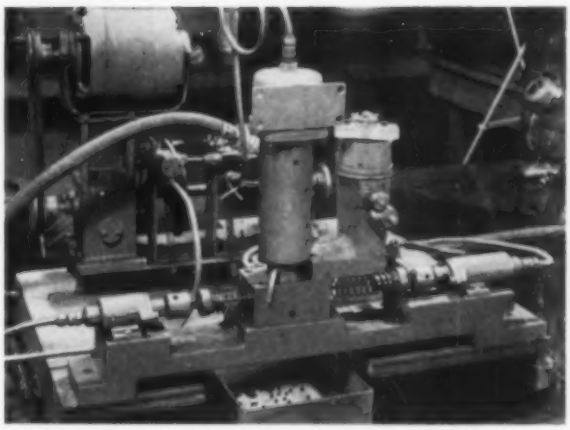
Concentric Dial Assembly

Designed for use with miniature servo breadboard systems, this assembly may be mounted so that the dial face is either parallel or perpendicular to the mounting surface. Input can be made perpendicular to the axis of rotation of the dial by the incorpora-

(Continued on page 320)

***Progress** in designing air systems:*

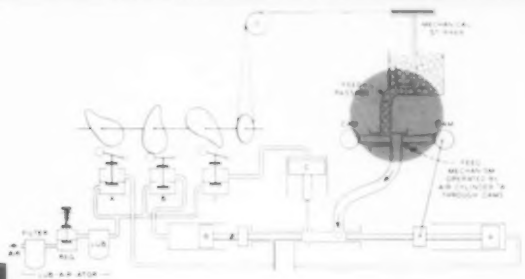
Here's another automating idea: Schrader Air Products in a multi-step punching system



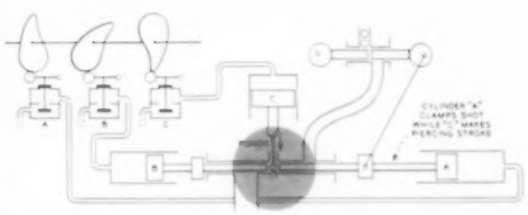
Schrader Products successfully performing at prominent Western plant—feeding, shot-piercing, ejecting—all automatically with air.

PROBLEM: To pierce tiny balls of lead shot, fast, accurately, and economically.

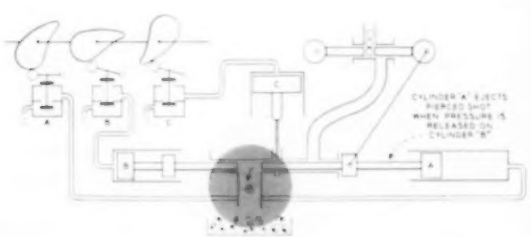
SOLUTION: Schrader Air Products designed into a system for automatic operation.



1 **FEED:** Performance of the cylinders in this system is controlled by cam-actuated Schrader valves. Cylinder A controls split-cam feed; allows the shot to be fed into the machine one at a time.



2 **PIERCE:** The shot is pushed forward and clamped at the piercing station by cylinder A and cylinder B. Cylinder C pierces the shot.



3 **EJECT:** Cylinder B returns to its initial position. Cylinder A completes its forward stroke, ejecting the pierced shot. And cycle starts again.

Air's benefits apply in almost any operation you can name: stamping, forming, programming, squeezing or measuring. And the advantages are more important today than ever: speed, accuracy, safety, simplicity, versatility, and—amazing economy. Schrader components are a natural for the designer because they comprise the only complete line of air products to select from. They can be used singly or in combination to perform jobs of amazing variety and complexity. When you design, think of air, and make use of Schrader's engineering facilities to help you specify the right products for your idea. Mail the coupon today.

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Please send latest informative booklets which show Schrader's complete line of Air Control Products.

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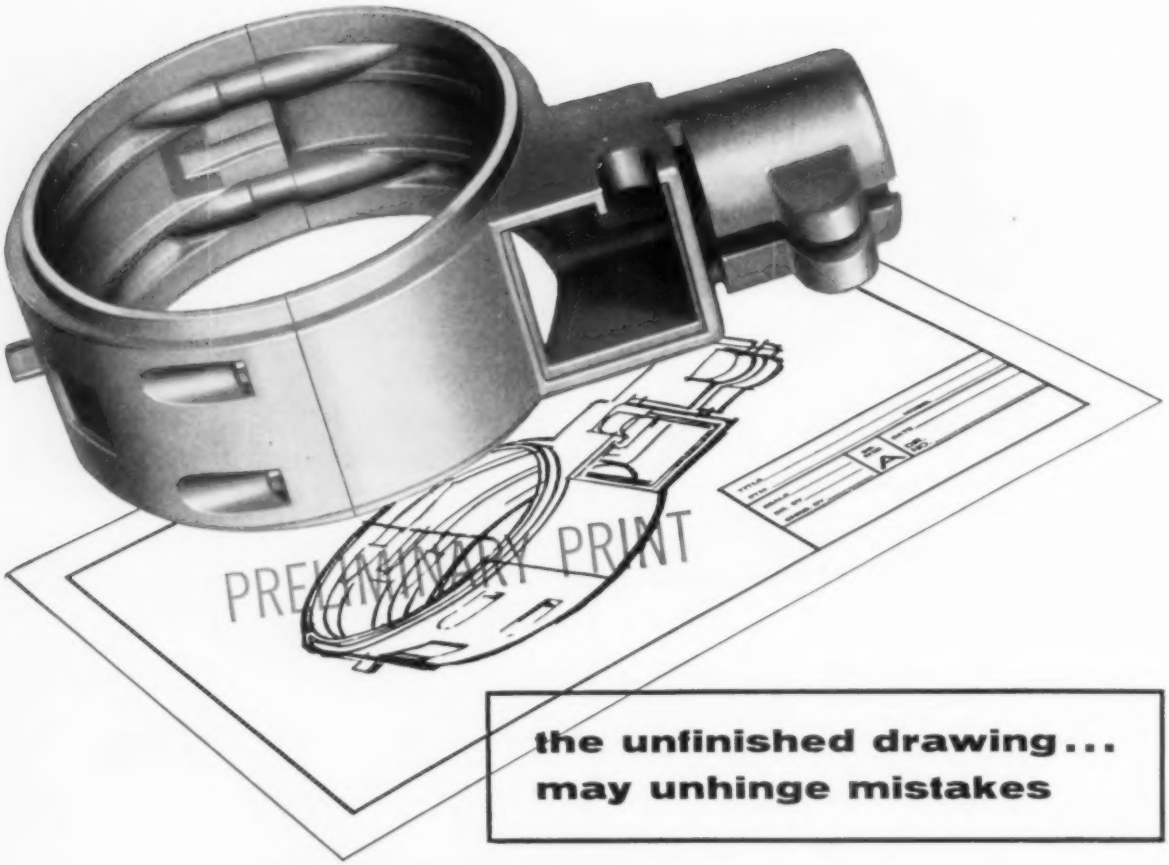

the unfinished drawing...
may unhinge mistakes

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The most successful product designers we know of, are those who send us their early sketches for review.

A die casting die represents the part drawing "turned inside out." Our practiced and practical die designers can do the turning mentally to expose any trouble spots in die making and die operation. Early design changes may promote substantial economies. They almost always advance time schedules.

It is standard procedure for our customers of long standing to send us their drawings as soon as there are enough lines to reveal the part design.

Please clip this ad as a reminder to contact us when you have die casting requirements.

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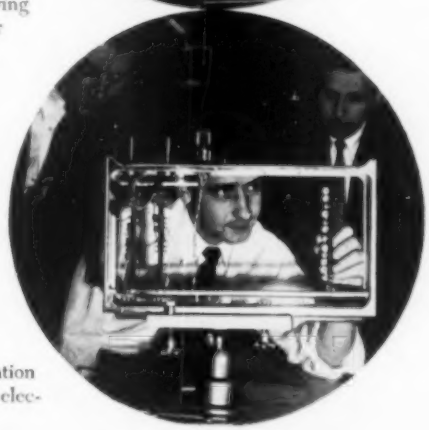

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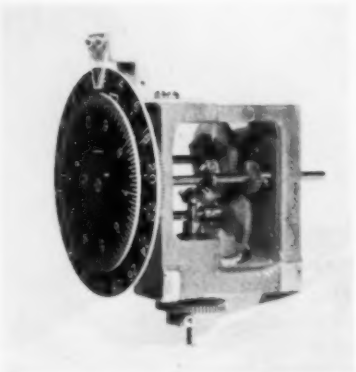

tion of a pair of miniature spiral mitre gears. There are separate inputs to the dials.

Gears used are AGMA Class II. A self-contained hair-line indicator ensures accurate dial reading. Hand control of the dial is provided by a knurled knob which can be attached to the dial hub. The dial assembly is a two-speed indicator, with standard ratios of 10:1 or 36:1 available. Reeves Instrument Corp., 207 E. 91 St., New York 28, N. Y.

For more information—
Circle 97, inside back cover

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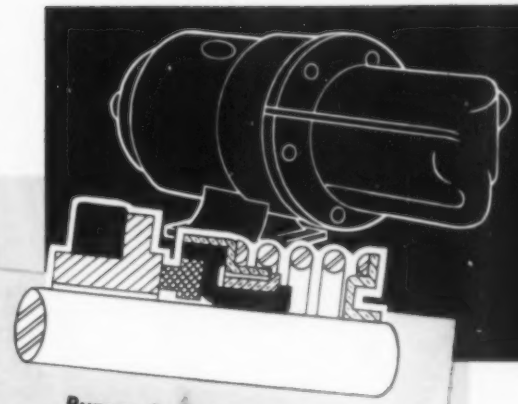
For more information—
Circle 98, inside back cover

Machine Tools And Power Transmission Equipment

STYLE GU — A packaged sealing unit containing both rotating and stationary seal faces enclosed in metal housing. Stock sizes for shafts .250 through 4.000.



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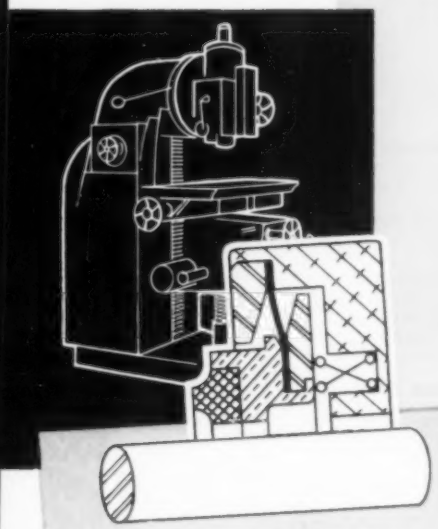

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STYLE DPC — A high-speed, carbon-faced seal, for more compact installation in heavy industrial machinery. Stock sizes for shafts .250 through 4.000.

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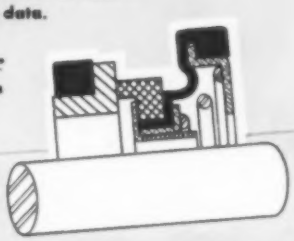
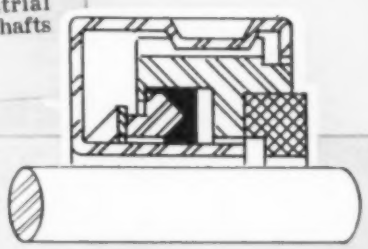


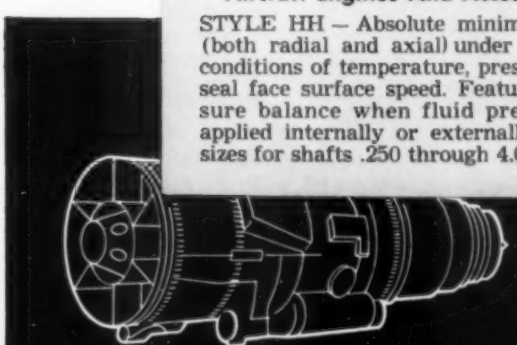
Household Appliances

STYLE SGU—A factory-assembled unit-type seal for the small-budget user. Stock sizes for shafts .250 through 1.000.



Aircraft Engines And Accessories

STYLE HH — Absolute minimal space (both radial and axial) under extreme conditions of temperature, pressure and seal face surface speed. Features pressure balance when fluid pressure is applied internally or externally. Stock sizes for shafts .250 through 4.000.



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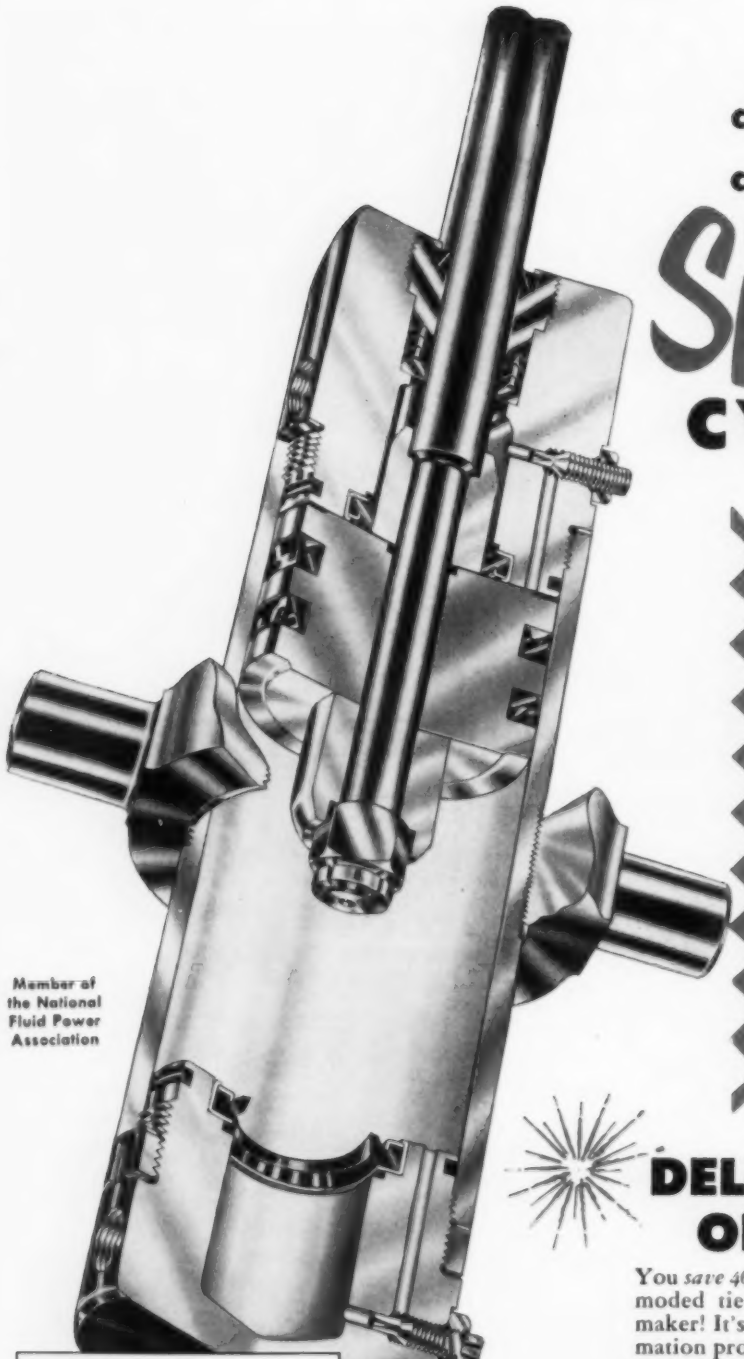

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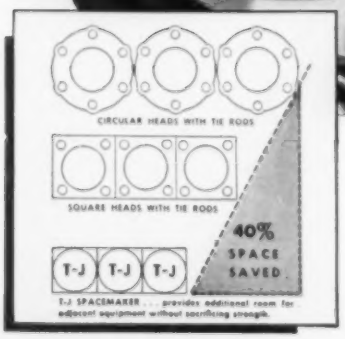
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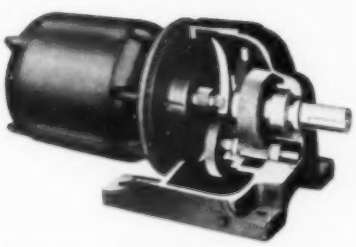

Parallel Shaft, Series 6000 — Foot Mounted
Gear case and motor integrally mounted
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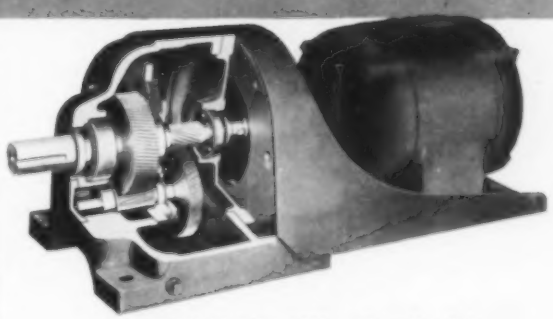
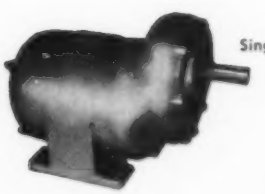
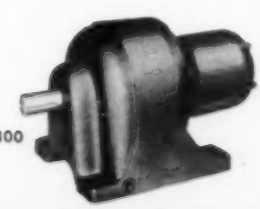


Parallel Shaft, Series 6000 — Motor Coupled
Gear case with mounting bracket and foot mounted motor
1 through 60 horsepower



Single Reduction, Series 6100
Foot Mounted

Double Reduction, Series 6200
Motor Coupled



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Triple Reduction, Series 6300
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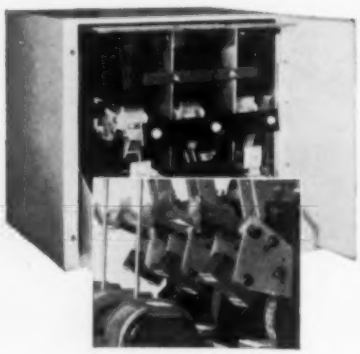

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CATALOGS and BULLETINS

To obtain copies of literature described below, circle corresponding number on postcard inside back cover. For those catalogs and bulletins available only when requested on company letterhead, see page 343.

High-Temperature Glass–Bulletin, 6 pp. Contains data and tables on new glass material called, Pyroceram. Material is lighter than aluminum and harder than some stainless steels. It is non-porous and may be formed by conventional glass-forming methods. Corning Glass Works, Corning, N. Y.

Circle 99, inside back cover

Stainless Steel Sheet and Strip–Booklet, 32 pp. Has more than 20 tables including data on a stainless steel finder, corrosion resistance of various stainless steels, fabrication properties, and weight tables per lineal foot in various widths and gages. There are sections on the proper selection of stainless steel grades, and an industry index of applications. Allegheny Ludlum Steel Corp., Oliver Bldg., Pittsburgh 22, Pa.

Circle 100, inside back cover

Gasket and Packings–Catalog, 48 pp. Contains information on industrial gaskets, mechanical packings, boiler gaskets, radio speaker gaskets, parking hooks, and steel rule dies. A special section includes a gasket recommendation chart, material comparative cost graph, gasket fault elimination chart, mechanical formulas and decimal equivalents table. Rhopac, Inc., 3425 Cleveland St., Skokie, Ill.

Circle 101, inside back cover

The Profession of Industrial Design–Booklet, 12 pp. Contains information on design and top management; types of design service; choosing consultant designer; cost factors; and the relationship between the industiral designer and his client, his colleagues and the public. American Society of Industrial Designers, 48 E. 49 St., New York 17, N. Y.

Circle 102, inside back cover

Properties of Zirconium–Memo 112, 5 pp. Physical properties of zirconium and its alloys and the mechanical properties of three different tempers of these metals is discussed. Superior Tube Co., 1556 Germantown Ave., Norristown, Pa.

Circle 103, inside back cover

Expansion Joints–Bulletin, 12 pp. Describes the characteristics and limitations of seven styles of expansion joints and couplings. Garlock Packing Co., 408 Main St., Palmyra, N. Y.

Circle 104, inside back cover

Motors, Fans and Blowers–Catalog, 14 pp. Contains specifications and electrical characteristics of synchronous, torque, induction and gear motors; centrifugal blowers and axial fans. Ashland Electric Products, Inc., 32-02 Queens Blvd., Long Island City 1, N. Y.

Circle 105, inside back cover

Flexible Metal Hose and Bellows–Catalog 156, 16 pp. Contains data and drawings on materials and fitting attachments. Flexonics Corp., 1351 S. 3 Ave., Maywood, Ill.

Circle 106, inside back cover

Properties of Selected Commercial Glasses–Bulletin B83, 16 pp. Discusses mechanical, thermal, electrical and chemical properties of glass. Viscosity temperature curves for several commercial glasses, and heat transmission data are also included. Corning Glass Works, Corning, N. Y.

Circle 107, inside back cover

High Speed Rotary Switches–Brochure, 4 pp. Contains data and diagrams on units for telemetering, sampling and programming. Instrument Development Laboratories, Inc., 67 Mechanic St., Attleboro, Mass.

Circle 108, inside back cover

Small Panel Meters–Brochure, 6 pp. Contains data on 250° arc angle meters. Hickok Electrical Instrument

(Continued on page 327)

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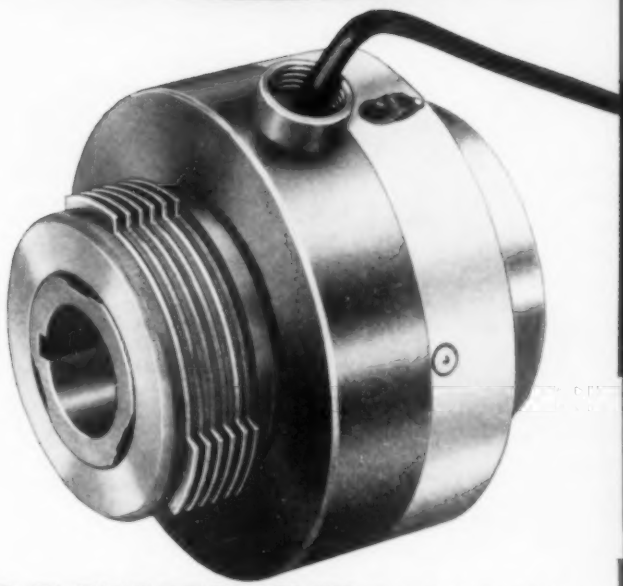
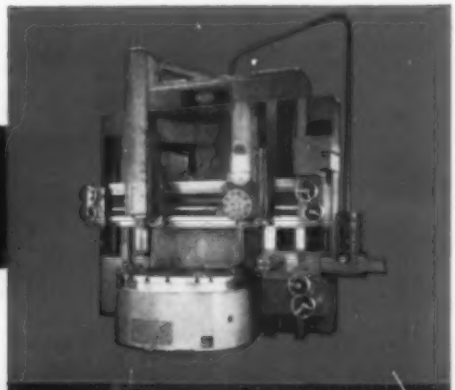
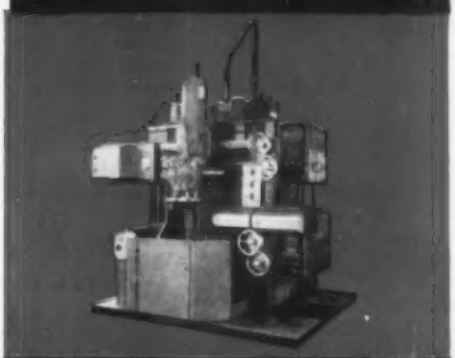
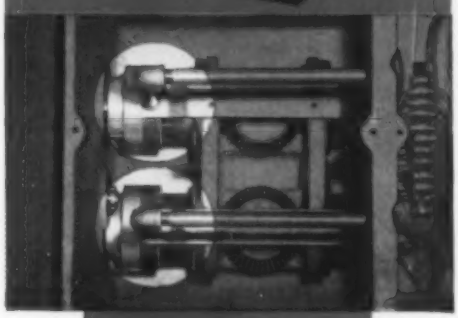




Above: Maxitorq Single and Double Electric Clutches on Bullard Cut-Master Model 75 Machines with single angular turning attachment.

Below: 2 Maxitorq Single Electric Clutches on Bullard Man-Au-Trol Model 75 Machines with double angular turning attachment.





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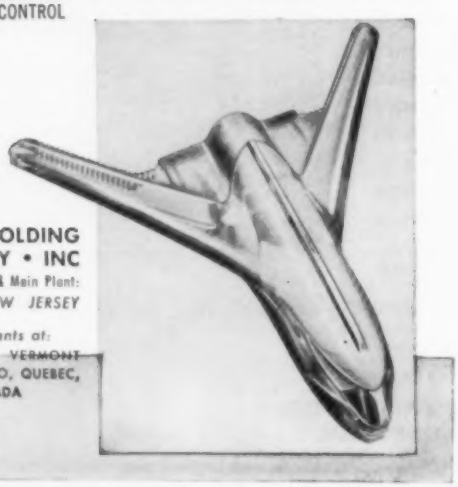

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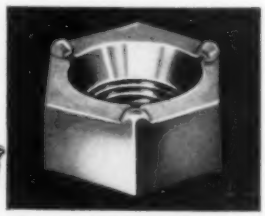

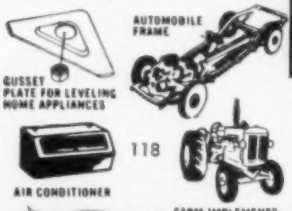

Gripco Countersunk Weld Nut eliminates time-wasting retapping of nuts after welding. Exclusive countersunk nut bottom eliminates fouling of threads by weld spatter. No time wasting false starts, no cleaning of damaged threads, nut ready to receive bolt immediately.

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Circle 109, inside back cover

D-c Timing Motors–Bulletin AWH-MO805, 2 pp. Contains information on the function of three basic d-c motors in voltage ratings from 4½ to 30 v. A. W. Haydon Co., Waterbury, Conn.

Circle 110, inside back cover

Electrical Connectors–Catalog K6, 64 pp. Contains information on units designed for use in aircraft, radio, instruments and general electrical equipment. They are available in seven basic shell types having eight insert sizes, totaling more than 220 arrangements with a variety of amperage and voltage ratings. Cannon Electric Co., 3208 Humboldt St., Los Angeles 31, Calif.

Circle 111, inside back cover

Hot Work Die Steel–Bulletin, 4 pp. Contains data covering elevated temperature physical properties meeting aircraft specifications for structural parts. Firth Sterling Inc., 3113 Forbes St., Pittsburgh 30, Pa.

Circle 112, inside back cover

How to Develop Successful New Products–Booklet, 24 pp. Gives suggestions on reducing research expense; offers procedures to help increase sales, cut costs, and increase profits. Foster D. Snell, Inc., Dept. 151, 29 W. 15 St., New York 11, N. Y.

Circle 113, inside back cover

Fhp Motors–Bulletin, GEA 6424, 16 pp. Contains data on motors used on such applications as power tools, heating and ventilating equipment, compressors, fans, water pumps, and machine tools. General Electric Co., Schenectady 5, N. Y.

Circle 114, inside back cover

Single-Phase Induction Motors–Bulletin GEC 1419, 4 pp. Gives application data, types, ratings, frame sizes, and construction features of motors for fans, blowers and pumps. General Electric Co., Schenectady 5, N. Y.

Circle 115, inside back cover

Reversible Geared Motors–Catalog GR 2, 4 pp. Contains data on units designed for use in servomechanisms,

(Continued on page 330)

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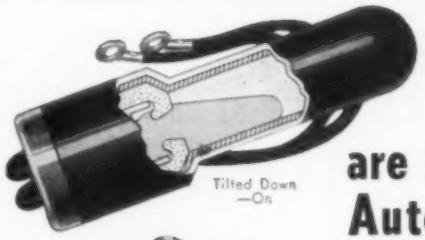

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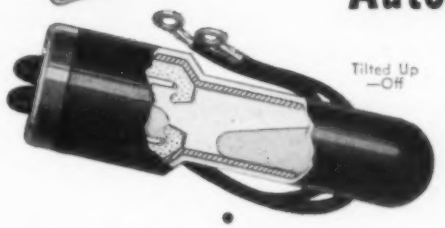

This steel-clad Durakool mercury tilt switch has unique construction features that deliver years of trouble-free performance on the most difficult assignments you can find. Operating under sealed-in, pressurized hydrogen gas, it takes 24 hours, fast cycling schedules in stride. 7 sizes, 1 to 65 amperes. Send for Bulletin 525.

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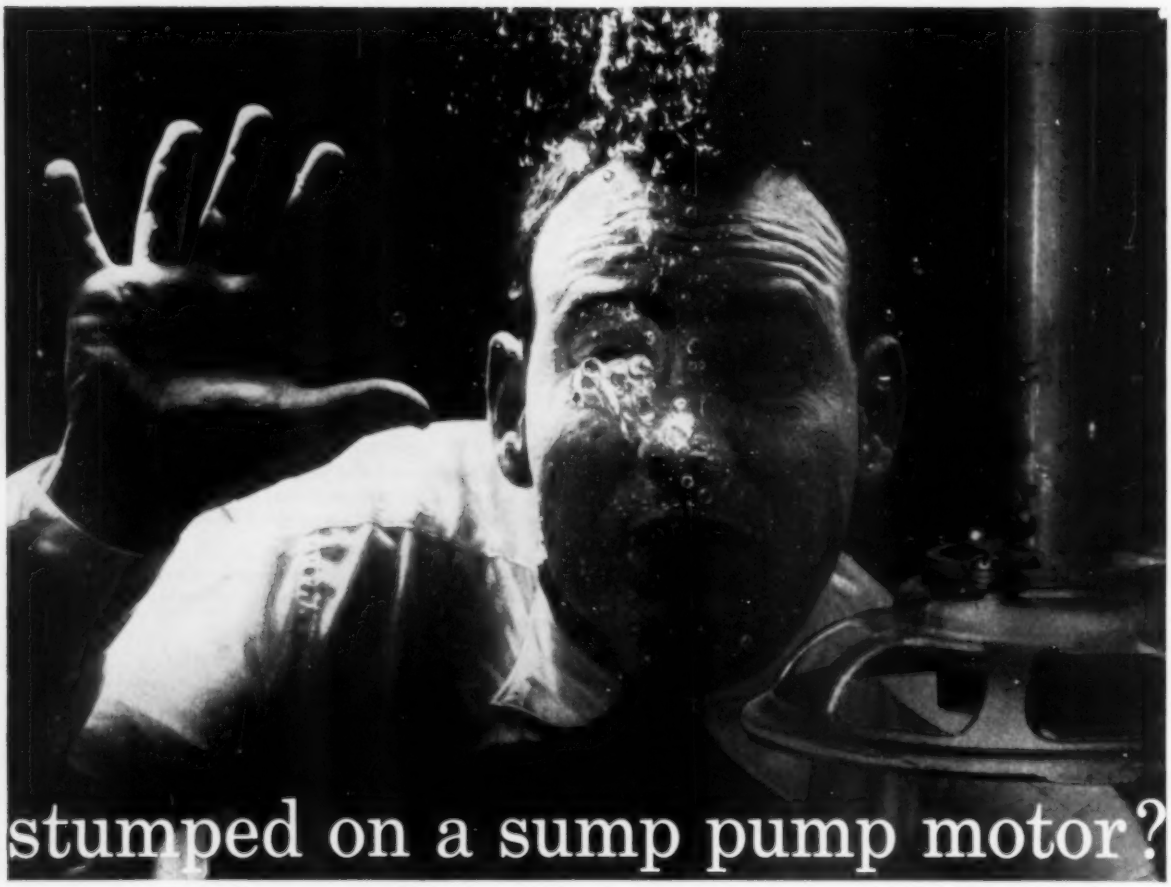
® Durakool ALL-STEEL MERCURY Switches



stumped on a sump pump motor?

want easy mounting, long life, quiet operation?

You know best what you want in an FHP motor for your product. Proper hub mountings, of course . . . easy connections on a modern terminal board, certainly. And compact design, quiet operation and long, dependable life, *to be sure!* And now you can upgrade your pumps at no extra cost!

The Westinghouse Custom Line offers you . . .

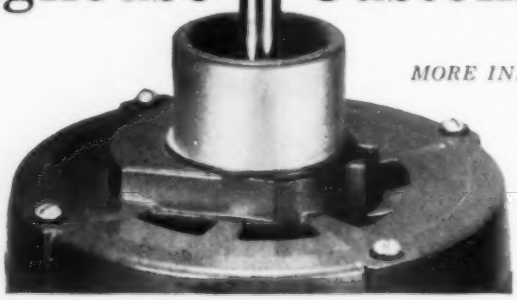
- Two rear-extended hub mountings with a combination of dimensions for *your* pump.
- Easy connections on a modern terminal board — plenty of room for electricians to work.
- Moisture-proof windings dipped in thermosetting varnish and baked for high bonding strength.
- Long life with 22% greater oil capacity, plus ⅝" diameter bearings, assuring cool, quiet operation.
- Thermoguard® protection (optional feature). A thermally operated relay that breaks the current under overload conditions.

J-03040

see the Westinghouse Custom Line!

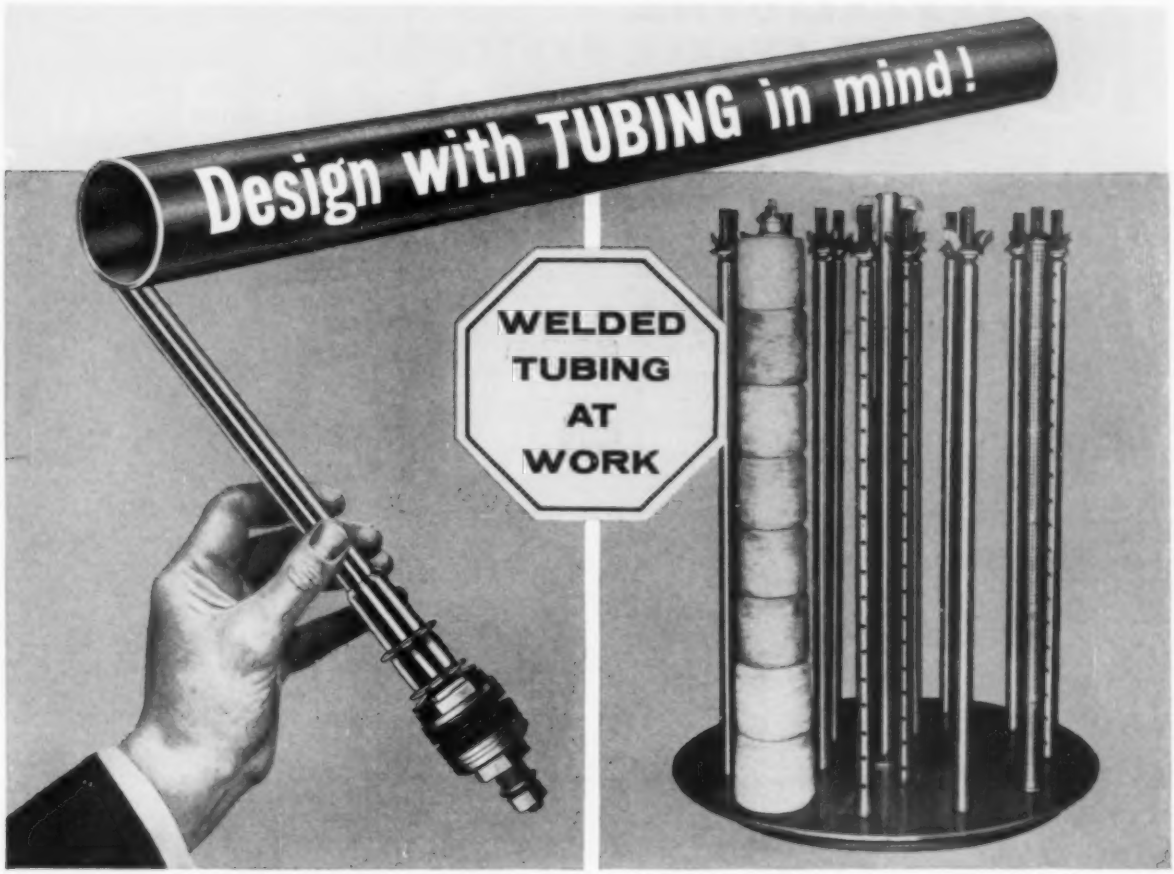
YOU CAN BE SURE...IF IT'S
Westinghouse

SMALL MOTOR DIVISION—LIMA, OHIO



MORE INFORMATION?

Just call your nearest Westinghouse sales engineer or write to Westinghouse Electric Corporation, Small Motor Division, Lima, Ohio.



This spindle turns at 10,000 RPM without a jitter—that's the benefit of Welded Carbon Steel Tubing's "on-center" uniformity of roundness, wall thickness and concentricity.

Corrosion Resistant Welded Stainless Steel Tubing withstands constant contact with chemical dyes, pressure and wear in this packaging yarn dyeing equipment.

For 10,000 RPM's or fighting corrosion

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NEW CALIDYNE 177 SHAKER SYSTEMS

The Model 177 is one of a new series of "wide-band" shakers designed for higher frequency operation and lower input requirements. It is the Basic Unit for five completely integrated CALIDYNE Vibration Test Systems. Oscillatory linear forces up to 5000 lbs. are generated and precisely controlled over wide ranges for vibration research and test of products up to 411 lbs. maximum load. Any of these five Vibration Test Systems using this New Model CALIDYNE 177 Shaker will enable you to:

1. Discover effects of "brute force" shaking on your assemblies and determine their ability to withstand vibrations far beyond those of normal operation.
2. Provide factual vibration data essential in determining mode shape, frequency and damping characteristics.
3. Determine results of fatigue testing at extremely high stresses and deflections.

CALIDYNE VIBRATION TEST SYSTEMS USING NEW MODEL 177 SHAKER

System Number		Type of Vibration	Force Output	Power Supply	Frequency Range	Maximum Load	
						10 g.	20 g.
1	177/80	Sinusoidal	3500 lbs.	Electronic	5-2500 cps.	261 lbs.	86 lbs.
2	177/180	Sinusoidal	5000 lbs.	Rotary	5-2000 cps.	411 lbs.	161 lbs.
3	177/186	Sinusoidal	5000 lbs.	Electronic	5-2500 cps.	411 lbs.	161 lbs.
4	177/190	Random or Sinusoidal†	5000 lbs.	Electronic	5-2500 cps.	411 lbs.	161 lbs.
5	177/190	Random†	5000 lbs.	Electronic	5-2500 cps.	411 lbs.	161 lbs.

†This system will perform with Random, Sinusoidal, Tape or Mixed Inputs.

A separate Bulletin 17700 details the specifications, performance data, basic components and accessories of the new Model 177 CALIDYNE Shaker and its five Shaker Systems. For engineering counsel in applying Controlled Vibration to your research and testing, call us here at CALIDYNE — WInchester (Boston) 6-3810.

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voltage regulators, combustion and industrial controls. Voltages from 6 to 220 v a-c, starting torques to 50 lb-in. Barber-Colman Co., 1400 Rock St., Rockford, Ill.

Circle 116, inside back cover

Hose Clamps—Catalog A457, 4 pp. Describes units for automotive, industrial and many other applications. Wittek Mfg. Co., 4305-37 W. 24 Place, Chicago 23, Ill.

Circle 117, inside back cover

Miniature Electrical Connectors—Catalog, 24 pp. Contains diagrams, data, and charts showing contacts and alternate insert positions. Deutsch Co., 7000 Avalon Blvd., Los Angeles 3, Calif.

Circle 118, inside back cover

Electric Clips—Catalog, 8 pp. Contains diagrams and data on alligator-type and miniiature test clips. Mueller Electric Co., 1552W E. 31 St., Cleveland 14, Ohio.

Circle 119, inside back cover

Adhesives and Sealers—Bulletin 650A, 4 pp. Contains data on recommended use, method of application and properties of eight adhesives, coatings and sealers. Raybestos-Manhattan, Inc., Bridgeport 2, Conn.

Circle 120, inside back cover

Diaphragm Valves—Catalog 104, 12 pp. Describes valves for positive closure. Hills-McCanna Co., 2430 W. Nelson St., Chicago 18, Ill.

Circle 121, inside back cover

Non-Lubricated Bearings—Catalog, 16 pp. Describes bearings made from carbon graphite material designed to operate under high temperatures. Electro-Nite Carbon Co., 8601 Torresdale Ave., Philadelphia 36 Pa.

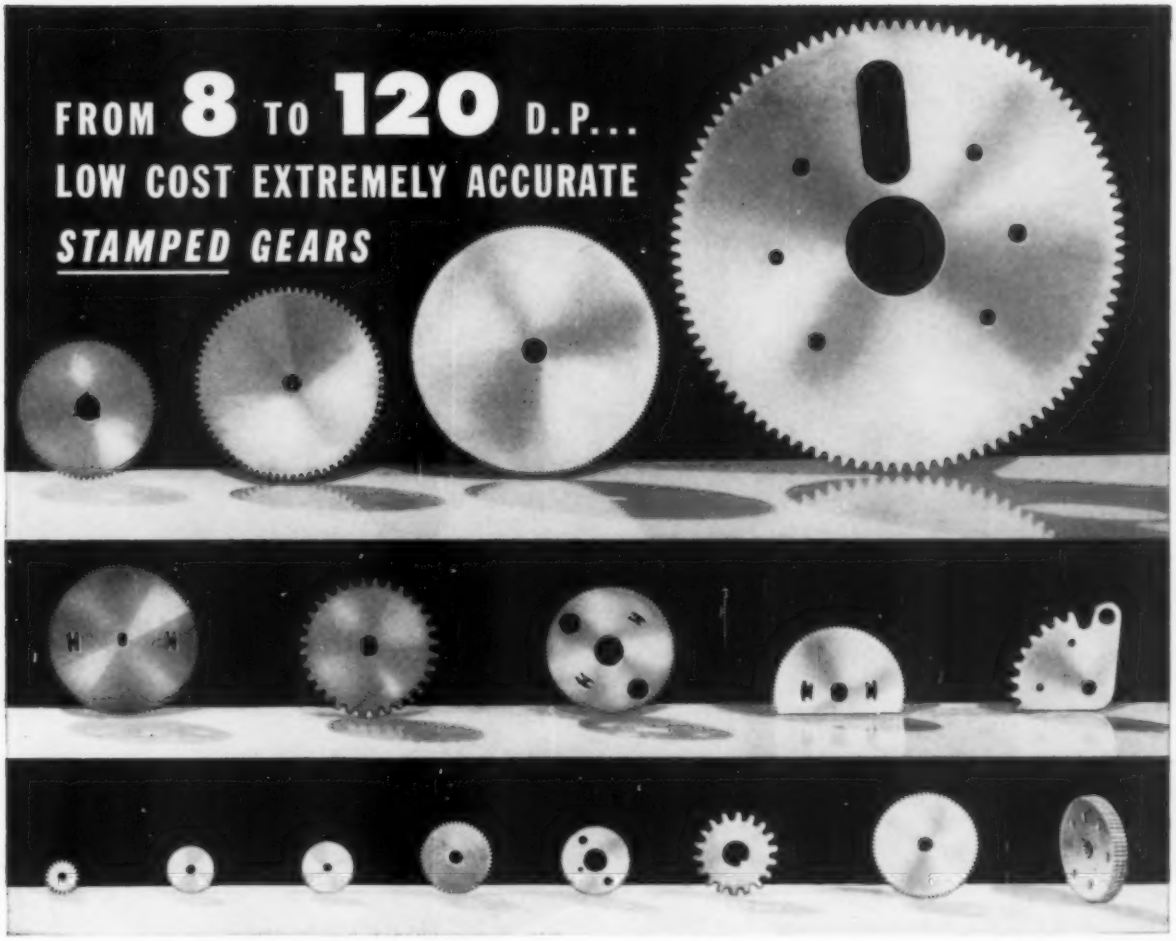
Circle 122, inside back cover

Temperature and Pressure Controls—Catalog, 96 pp. Contains data on regulators, pneumatic control instruments, indicating and recording instruments, control valves, and pneumatic motors. Powers Regulator Co., 3434 Oakton St., Skokie, Ill.

Circle 123, inside back cover

Lubricating System—Bulletin 70, 8 pp. Describes type of circulating oil sys-

(Continued on page 334)



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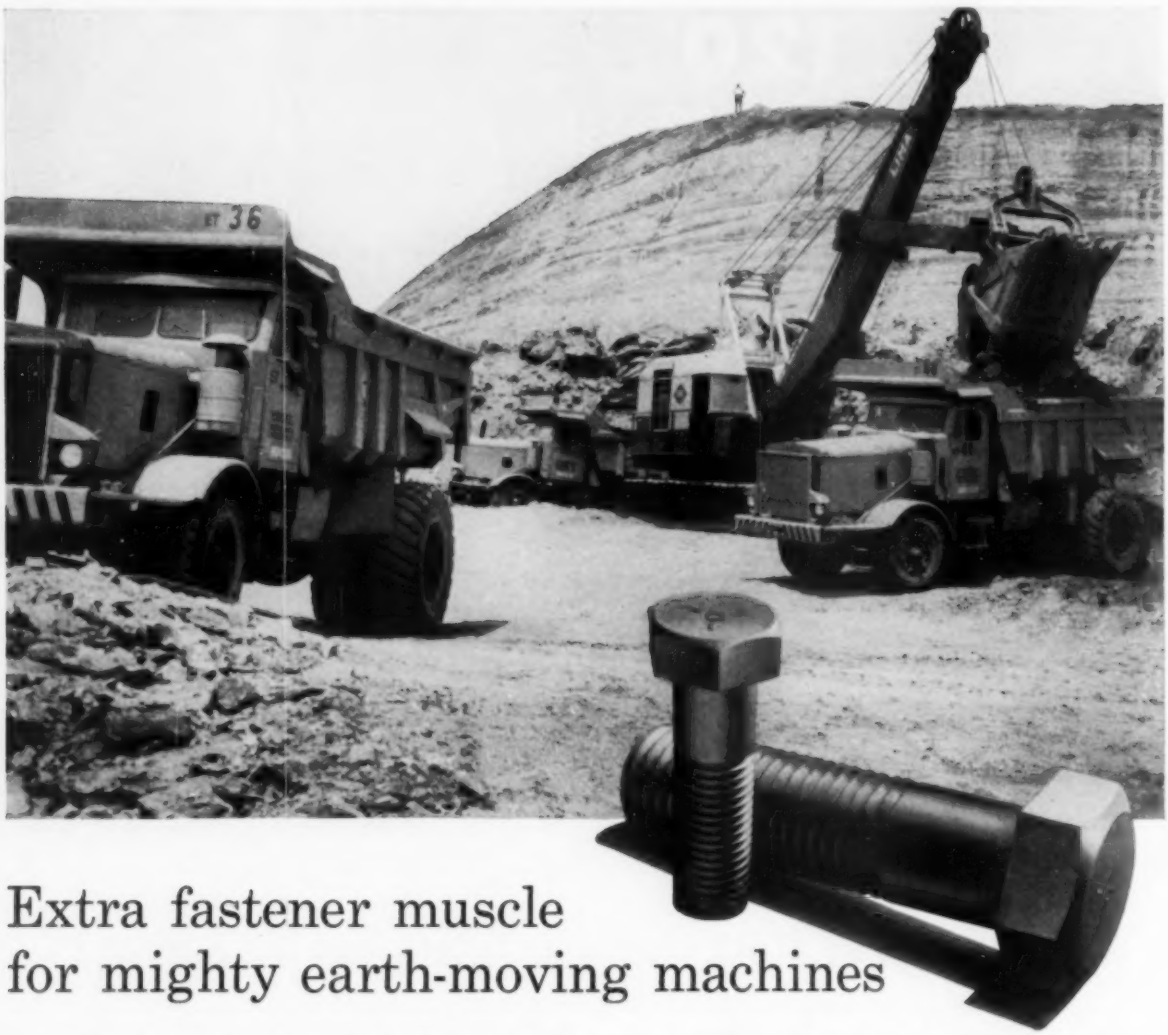
CLEVELAND STANDARD HEXAGON HEAD CAP SCREWS



Extra fastener muscle for mighty earth-moving machines

Power shovels, trucks, bulldozers—all take brutal shock loads and vibration, day in, day out. To reduce repairs and down-time to a minimum, leading manufacturers of earth-moving equipment specify Cleveland cap screws with confidence. These upset forged hexagon head cap screws put extra strength into every assembly, insure customer satisfaction.

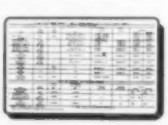
Cleveland standard hexagon heads are manufactured from various steels and in various tensile strengths. Included are extra-large diameters and long lengths. Bright and quenched and tempered steels in all standard sizes are ready for immediate delivery—alloy steels on short notice. Let our experienced engineers help you with your fastener problems. Remember, Cleveland has the most modern of production facilities and the world's largest stock of hexagon head cap screws.

TENSILE STRENGTHS OF CLEVELAND HEXAGON HEAD CAP SCREWS

Product	Size, in.	Tensile Strength, psi
Bright	Up to 7/8 incl. 1/2 to 1 1/2 incl. Over 1 1/2 to 1 1/2 incl.	85,000—105,000 75,000—100,000 65,000 min.
Quenched & Tempered (SAE Grade 5)	Up to 3/4 incl. Over 3/4 to 1 incl. Over 1 to 1 1/2 incl.	120,000 min. 115,000 min. 105,000 min.
Quenched & Tempered (SAE Grade 6)	Up to 3/4 incl. Over 3/4 to 3/4 incl.	140,000 min. 133,000 min.
Alloy (SAE Grade 7)	Up to 1 1/2 incl.	130,000 min.
Alloy (SAE Grade 8)	Up to 1 1/2 incl.	150,000 min.
Bright	Over 1 1/2 to 2 1/2 incl.	55,000 min.
Quenched & Tempered	Over 1 1/2 to 2 1/2 incl.	90,000 min.
Alloy	Over 1 1/2 to 2 1/2 incl.	125,000 min.

Note: Higher physicals, through use of selected alloys, can be supplied on special order.

GET YOUR COPY NOW — Pocket-size card giving you physical properties of Cleveland hexagon and socket head cap screws and Cleveland Place bolts.



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ESCO Spuncast is a homogeneous, pressure formed metal tube possessing chemical balances free from flow lines, forging or rolling stresses. A non-directional metal structure, available in many superior alloys, in sizes, grades and quantities not practical for large scale rolling mill production.

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tem for application on presses and semi-automatic or automatic machine tools. Farval Corp., 3249 E. 80 St., Cleveland 4, Ohio.

Circle 124, inside back cover

Stainless Steel–Data Sheet, 4 pp. Contains information on a special stainless steel that is used for jet engine parts, high-pressure stream valves, and steam and gas turbine parts. Type 418 special is recommended for application in the 750 to 1100 F range. Allegheny Ludlum Steel Corp., Oliver Bldg., Pittsburgh 22, Pa.

Circle 125, inside back cover

Guide for Spring Buyers–Booklet, 12 pp. Discusses manufacturing standards, price and quotation methods, refusals to quote, realistic spring tolerances, types of spring ends, finishes, packaging considerations, verification of quality, and reduction of rejects. Hunter Spring Co., Lansdale, Pa.

Circle 126, inside back cover

Nuclear Shielding–Brochure, 8 pp. Illustrates equipment and materials for gamma ray protection. Ameray Corp., Route 46, Kenvil, N. J.

Circle 127, inside back cover

Mercury Switches–Data sheet 114, 1 pp. Contains diagrams and data on units for small load circuits. Micro Switch, Freeport, Ill.

Circle 128, inside back cover

Extruded Plastics–Bulletin 105, 8 pp. Contains data and tables covering both tubing and rod made of plastics. Jessall Plastics, Inc., Kensington, Conn.

Circle 129, inside back cover

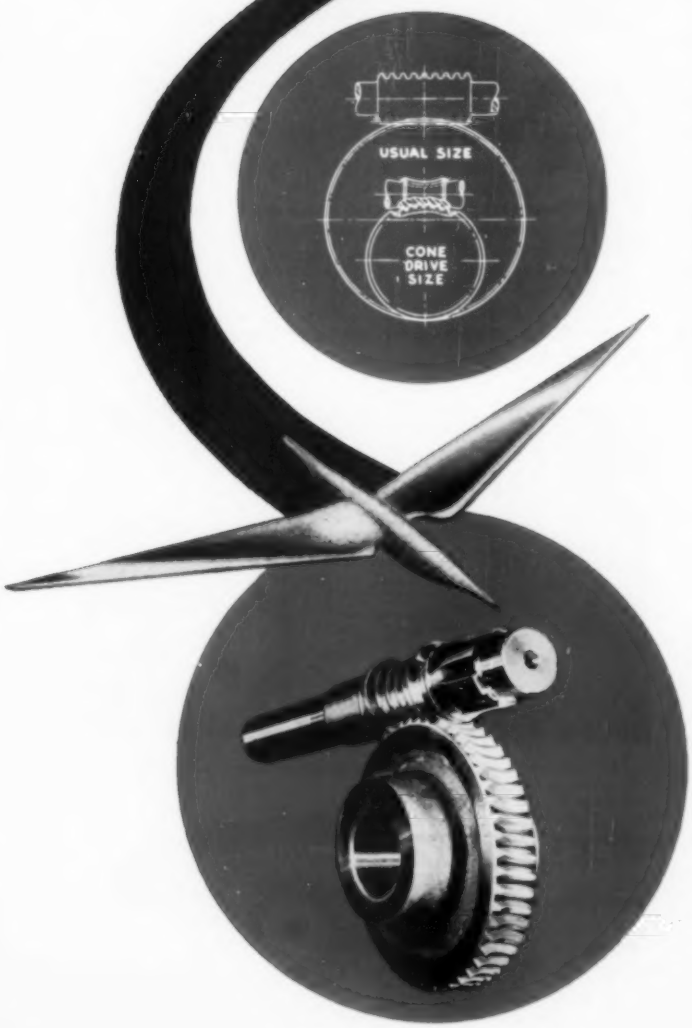
Gas Regulators–Catalog 806, 40 pp. Discusses various types of cylinder, manifold, and pipeline regulators, both single-and two-stage, and variety of specialized equipment such as laboratory and metering regulators and gas proportioners. Air Reduction Co., Inc., 150 E. 42 St., New York 17, N. Y.

Circle 130, inside back cover

Oil Capacitors–Catalog 1134, 4 pp. Contains data on "G"-type, oil-impregnated capacitors featuring a threaded,

(Continued on page 339)

for smooth power



. . . CONE-DRIVE gearing has no equal.

You can drive the most delicate equipment or the heaviest industrial machinery without vibration or noise through a set of Cone-Drive gears.

Smooth delivery of power is an outstanding feature of Cone-Drive double-enveloping worm gearing. It's the result of a unique design that puts one-eighth of all gear teeth in simultaneous, full-depth contact with the worm threads.

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Want smooth, chatter-free, efficient power in a compact package? Cone-Drive gears will give it to you in gearsets or speed reducers in a wide range of models and sizes.

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PLASTICS NEWSFRONT

SOCKETS TO MATCH YOUR '57 CHRISTMAS TREE

A more colorful Christmas—1957 is in the making today. To match the trend to Christmas trees sprayed in a host of colors, Conart Co., Inc., is now molding light socket husks in a variety of colored BEETLE® Molding Compounds to be strung on matching wire strands. Sturdy, hard BEETLE is an excellent insulator, and its molded-in color resists heat and discoloration, can't chip off. Conart produces enough husks each month to stretch twice from coast to coast.

LAMINAC® SIGNS WARN OF "OPERATION ELECTROCUTION"

These LAMINAC signs point to a great experiment in sea lamprey control being conducted by U.S. Fish and Wildlife Service in the Great Lakes area. To kill these destructive eellike fish, electrically charged lines are stretched across areas where lampreys return from spawning. Passers-by are warned off by signs posted on land and in the water. To make them waterproof, with warnings that can't wash off, Perry Plastics, Inc., makes the signs of glass-reinforced LAMINAC Polyester Resin. Color is molded in, so signs never need painting and will never rot or rust away.

ANGELIQUE'S CYMEL® AEROSOL WINS CSMA AWARD

1956 saw the first successful all-plastic aerosol spray dispenser made of CYMEL Melamine Molding Compound. And it brought the top Chemical Specialties Manufacturing Association, Inc. award in the class of glass and plastic aerosols to Angelique's CYMEL dispenser for Black Satin Spray Cologne. Plastic aerosols are popular with the ladies, too—feel warm and pleasant in the hand, resist breakage and corrosion, eliminate evaporation. Their success points the way to many new packaging possibilities with CYMEL.

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Install Spicer . . . for service where Super Strength is a Must!

MASSIVE construction . . . materials of exceptional durability . . . and efficient design are outstanding Spicer Heavy-Duty Clutch features. Trucks . . . fire apparatus . . . earth movers . . . industrial and railroad applications . . . these giant power-delivery jobs have been handled by Spicer Clutches for over 25 years.

BIG CAPACITY is built into Spicer Clutches with these features:

RELEASE PARTS WITH CLUTCH—The unit is complete with Release Bearing Assembly, Release Yoke and Cross Shafts ready for hookup to pedal linkage. No further engineering or procurement is required by purchaser.

LOWER HEAT ON SPRINGS—There is no direct contact between pressure springs and pressure plate, therefore, springs will not take a set and lose pressure due to heat.

REDUCED FRICTION—The knife edge design of the fulcrum points reduce friction which shows up as less pedal effort to release clutch.

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Ask Dana engineers to help meet your particular power transmission requirements. Dana has the clutch experience and the ability to do the job . . . the result of over 50 years of development in power transmission.

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Spicer Clutch Driven Disc Types to Meet Every Need

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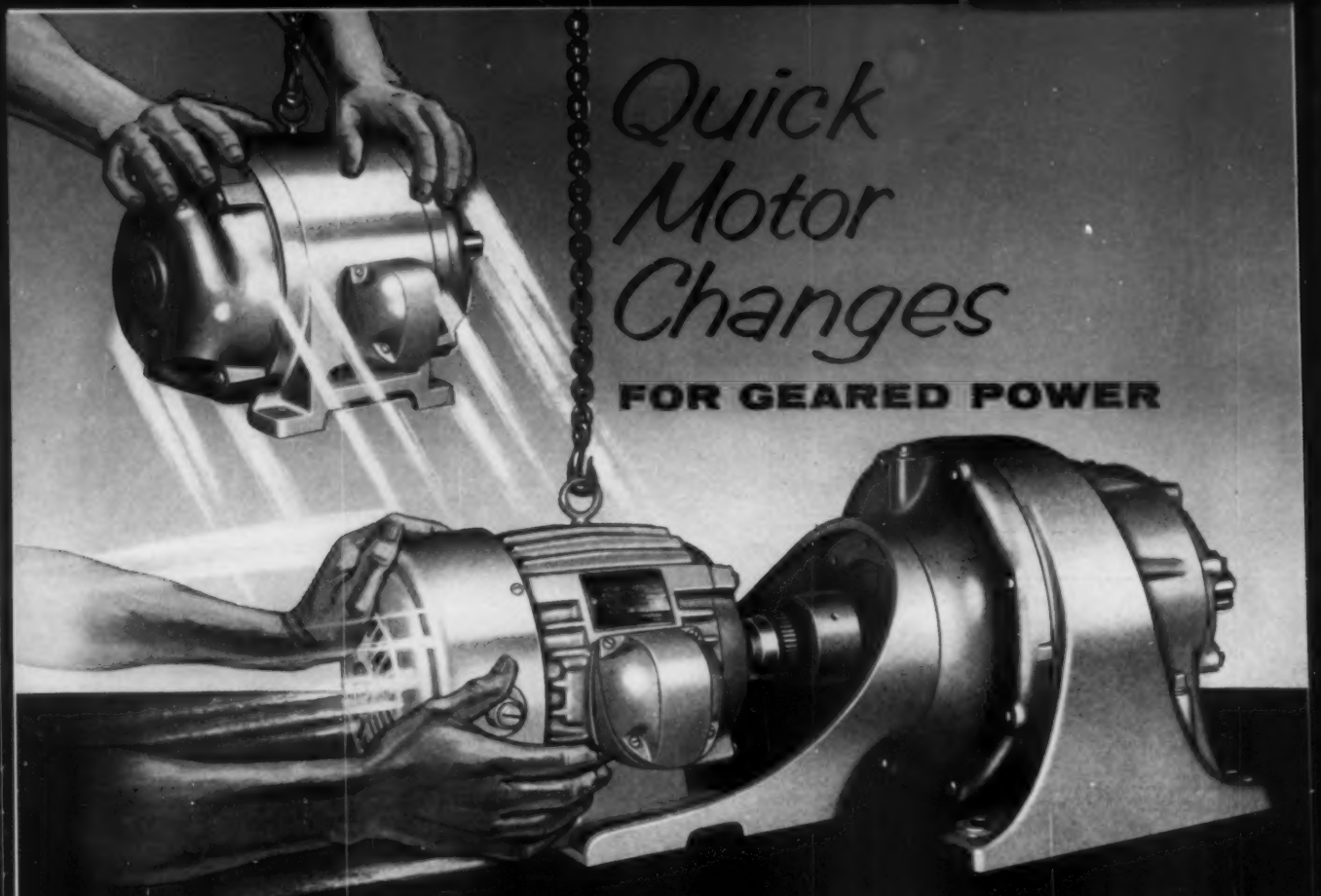

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FOR GEARED POWER

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In one compact power package a high-speed NEMA foot-mounted motor and a low-speed, double reduction gear transmission. Motor change in minutes! And with U. S. Motomount Syncrogear, the change is not limited to the type motor being replaced! If *you* carry a spare motor inventory, here is real flexibility and quick-change. U. S. Uniclosed, Totally-Enclosed, or Explosion-Proof motors of the same NEMA dimensions and ratings may be used to meet changing requirements. Available in h.p. ratings 1 to 30. U. S. Motomount Syncrogear has solid shank ever-tight pinion, friction-free oil seal, thru-hardened gears—many advanced features for longest life.

MOUNTS LIKE AN INTEGRAL UNIT, FOR INHERENT ALIGNMENT... Both units of the U. S. Motomount Syncrogear have rugged, pyramidal base construction—made-to-match pyramids to hold motor and mount aligned for life—factory alignment PLUS centralized responsibility for manufacture of both components.

CAST IRON FOR ALL EXTERNAL PARTS . . . For tough, industrial duty! Besides providing structural stability, cast iron protects against corrosive elements. All castings normalized for permanent retention of precision machining.

TAKES THE NEW RE-RATED NEMA MOTORS... U. S. Motomount Syncrogear takes the re-rated NEMA motors in the new sizes. The wide range thus acceptable enables you to reduce spare motor inventory!

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molded mounting neck. Industrial Condenser Corp., 3243-65 N. California Ave., Chicago 18, Ill.

Circle 131, inside back cover

Casters and Wheels–Catalog 125, 56 pp. Contains illustrations, descriptions and data on many types and sizes of casters. Included are: swivel and rigid casters, single and double wheel models, wheels, rubber tires, and flanged track wheels. Hamilton Caster & Mfg., 1700 Dixie Hwy, Hamilton, Ohio.

Circle 132, inside back cover

Stainless Steel Plug Valves–Bulletin S1, 2 pp. Describes Teflon-sleeved stainless steel units. Continental Mfg. Co., 247 Park Ave., New York 17, N. Y.

Circle 133, inside back cover

Hydraulic Power Units–Catalog, 52 pp. Contains information on pumps, cylinders, pressure switches and accessories. Oil-Dyne, Inc., 2115Z W. Marquette Road, Chicago 36, Ill.

Circle 134, inside back cover

Lubricants–Brochure, 16 pp. Contains data and charts on molybdenum disulfide. Alpha Molykote Corp., Stamford, Conn.

Circle 135, inside back cover

Insulating Materials–Brochure B7206, 8 pp. Contains data and charts discussing types, characteristics, and applications for shellac, varnished fabrics, slot cell insulation and organic varnished glass. Westinghouse Electric Corp., Box 2099, Pittsburgh 30, Pa.

Circle 136, inside back cover

Couplings–Catalog 140, 8 pp. Contains data and diagrams of unit used as a centrifugal clutch. Rawson Coupling Div., O. S. Walker Co., Inc., Worcester 6, Mass.

Circle 137, inside back cover

Heat Exchanger–Bulletin HT1A, 6 pp. Contains data on a fixed bundle unit for heating and cooling liquids. Yates-American, Beloit, Wis.

Circle 138, inside back cover

Turbine Flow Meter–Catalog, 4 pp. Contains data on unit to measure the rate of flow of liquids having flows

(Continued on page 341)

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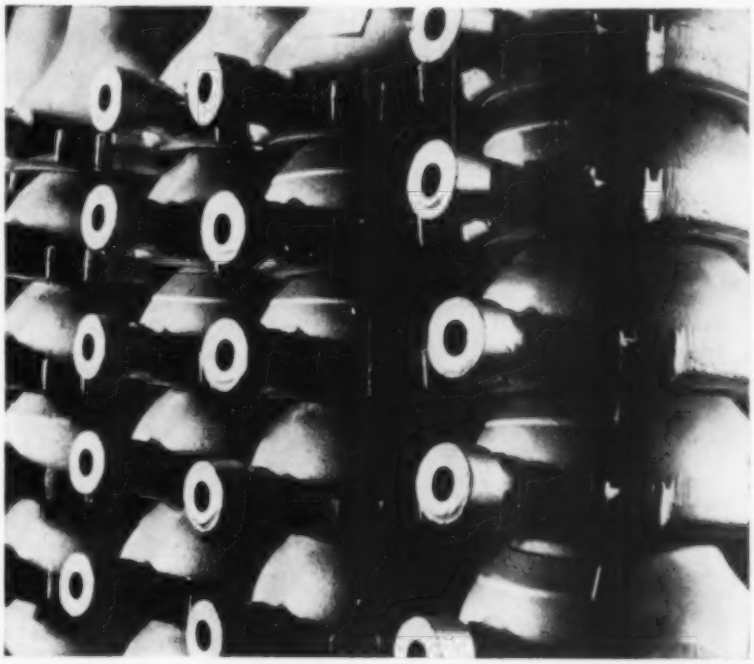

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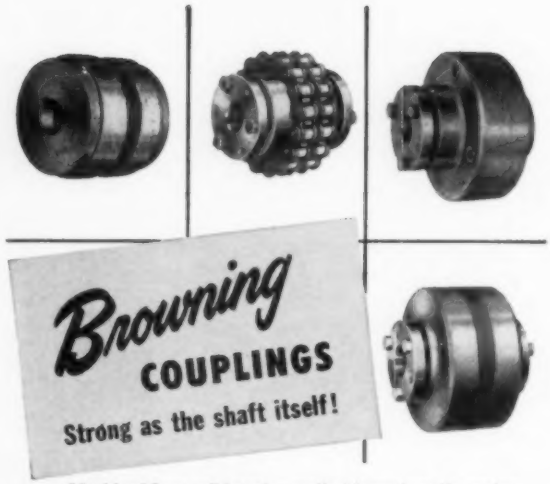

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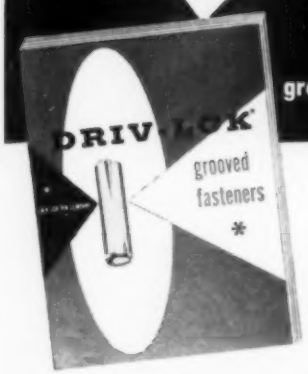

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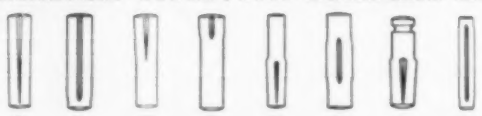

DRIV-LOK PIN COMPANY
723 Chauncey St. • Sycamore, Illinois

of from less than one gpm to more than 2500 gpm. Fischer & Porter Co., 75 Jacksonville Road, Hatboro, Pa.

Circle 139, inside back cover

Inserts–Bulletin 738, 8 pp. Contains tables and data on miniature size 4-40 units. Heli-Coil Corp., Danbury, Conn.

Circle 140, inside back cover

Battery Connectors–Catalog GB6, 32 pp. Contains data on heavy-duty units for general power use. Cannon Electric Co., 3208 Humboldt St., Los Angeles 31, Calif.

Circle 141, inside back cover

Zinc Coated Steel–Brochure, 12 pp. Contains specifications and applications of material. Weirton Steel Co., Weirton, W. Va.

Circle 142, inside back cover

Flexible Metal Hose – Catalog ID100A, 10 pp. Contains data on assemblies to transfer liquids and semi-liquids, solids, or solids in powder or granular form. Universal Metal Hose Co., 2133 S. Kedzie Ave., Chicago 23, Ill.

Circle 143, inside back cover

Spring Steel–Bulletin, 6 pp. Contains data and tables on specialty steels. Sandvik Steel, Inc., Fair Lawn, N. J.

Circle 144, inside back cover

Casters and Wheels–Catalog C-57, 12 pp. Contains diagrams and data on steel units for heavy duty and

(Continued on page 343)

"Miss Grooton!!"

THE SHAPE OF THINGS IN MOLDED SILICONE

MOLDED SILICONE SEAL
KEEPS TAP WATER UNDER CONTROL

APPLICATION:
Funnel seal for steam and dry iron.

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Maximum Serviceability
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Wide Choice of Insert Patterns (1 to 55 contacts)
Designed especially for miniaturized Electronic Equipment

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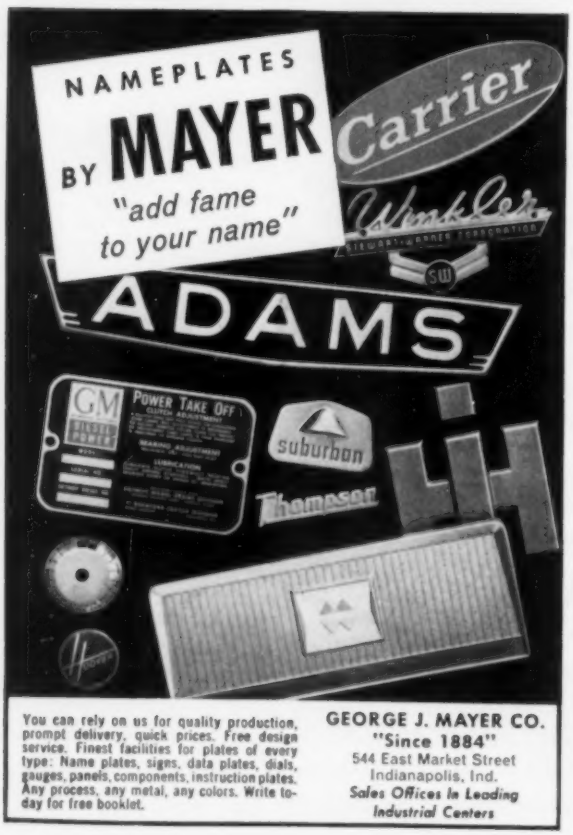

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Circle 145, inside back cover

Jig and Fixture Details–Catalog, 82 pp. Contains scale templates of fixture clamps, fixture keys, cams, screws, nuts, washers, handles, hand knobs and hand wheels. Harco Engineering, 12092 Woodbine Ave., Detroit 39, Mich.

Circle 146, inside back cover

Control Valves–Bulletin 571, 12 pp. Contains data on air and hydraulic units including sliding sleeve, single plunger, O-type and B-type. C. B. Hunt and Son, Inc., Salem, Ohio.

Circle 147, inside back cover

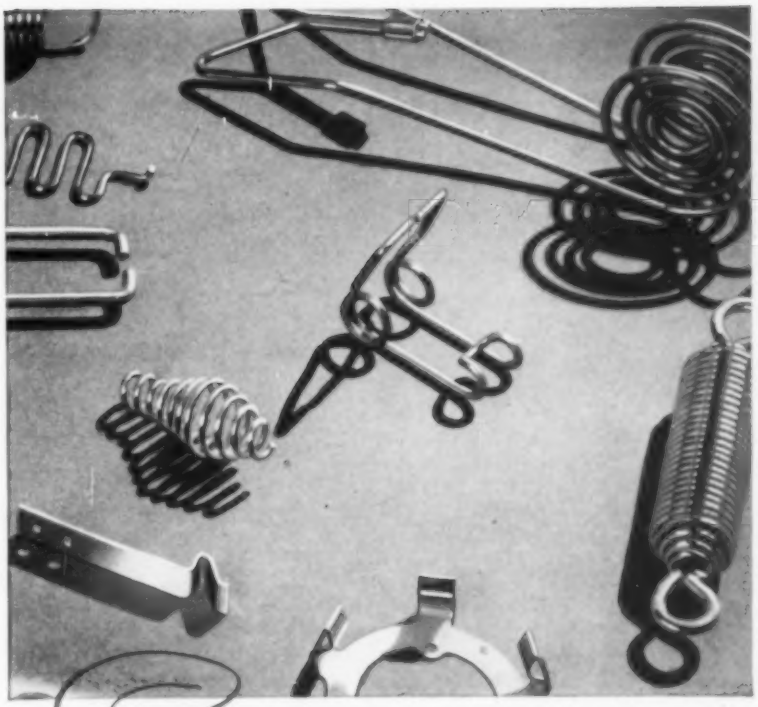
Letterhead Requests Only

Manufacturers who published following literature ask that requests for copies be made on company letterheads.

An Evaluation of Bend Testing of Titanium Sheet–Report 68, 22 pp. Contains data on procedures, recommendation and test information obtained. Titanium Metallurgical Lab., Battelle Memorial Institute, Columbus 1, Ohio.

V-Drives–Catalog, 56 pp. Contains information on fhp units, drive parts and accessories. Included is size data on bushed type and fixed bore type cast iron and pressed steel V-pulleys, V-belts, refrigeration fans and fan pulleys, and V-drive accessories. Maurey Manufacturing Corp., 2915 S. Wabash Ave., Chicago 16, Ill.

Aluminum Extruisons – Handbook, 130 pp. Contains data on the use of aluminum extrusions for structural, truck and trailer uses, as well as industrial product applications. Included are drawings of standard shapes available without die charge. Information is given on aluminum extrusion alloys, their mechanical and physical properties, tolerances, weights, manufacturing limits, etc., as well as data on fabricating and finishing. Bridgeport Brass Co., Bridgeport 2, Conn.



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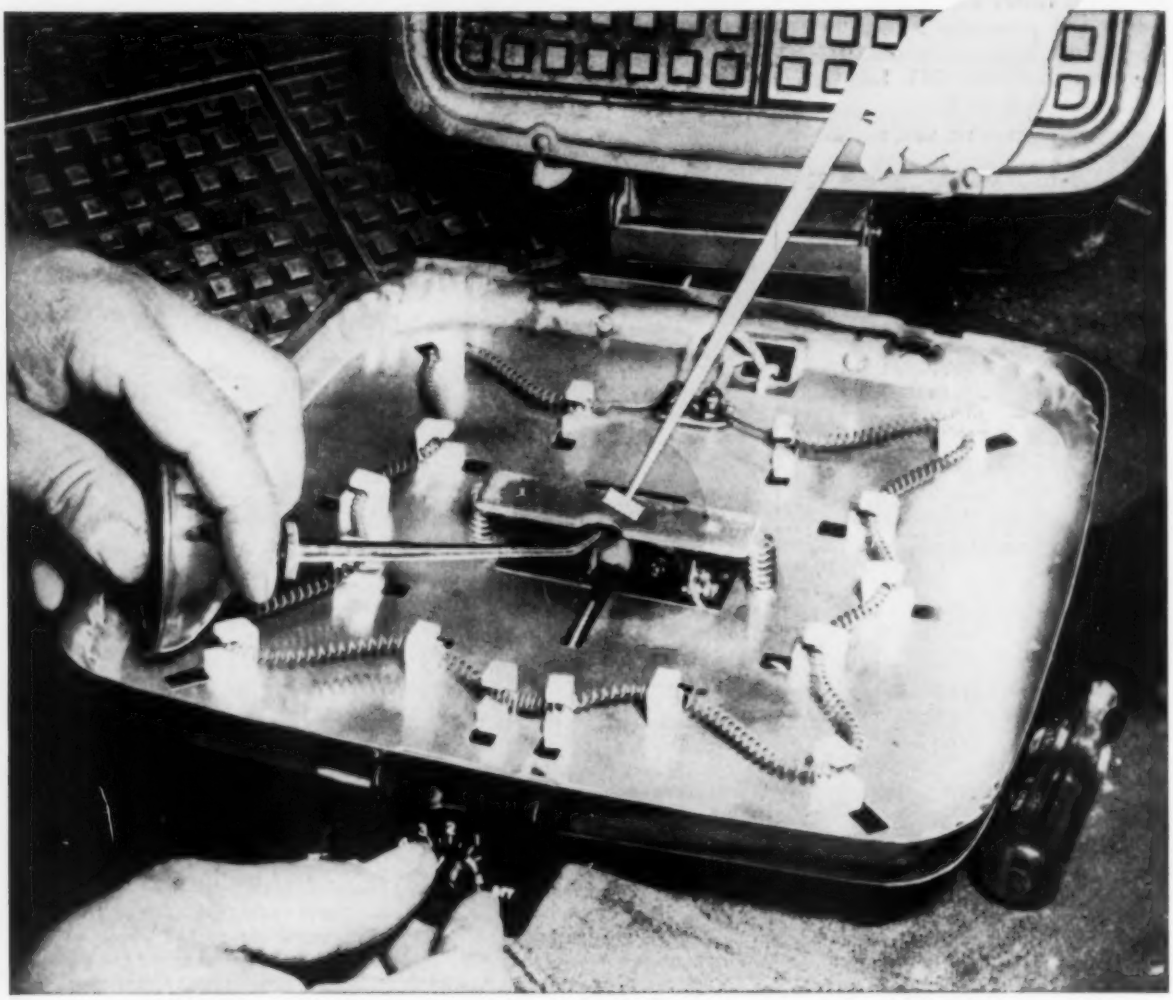

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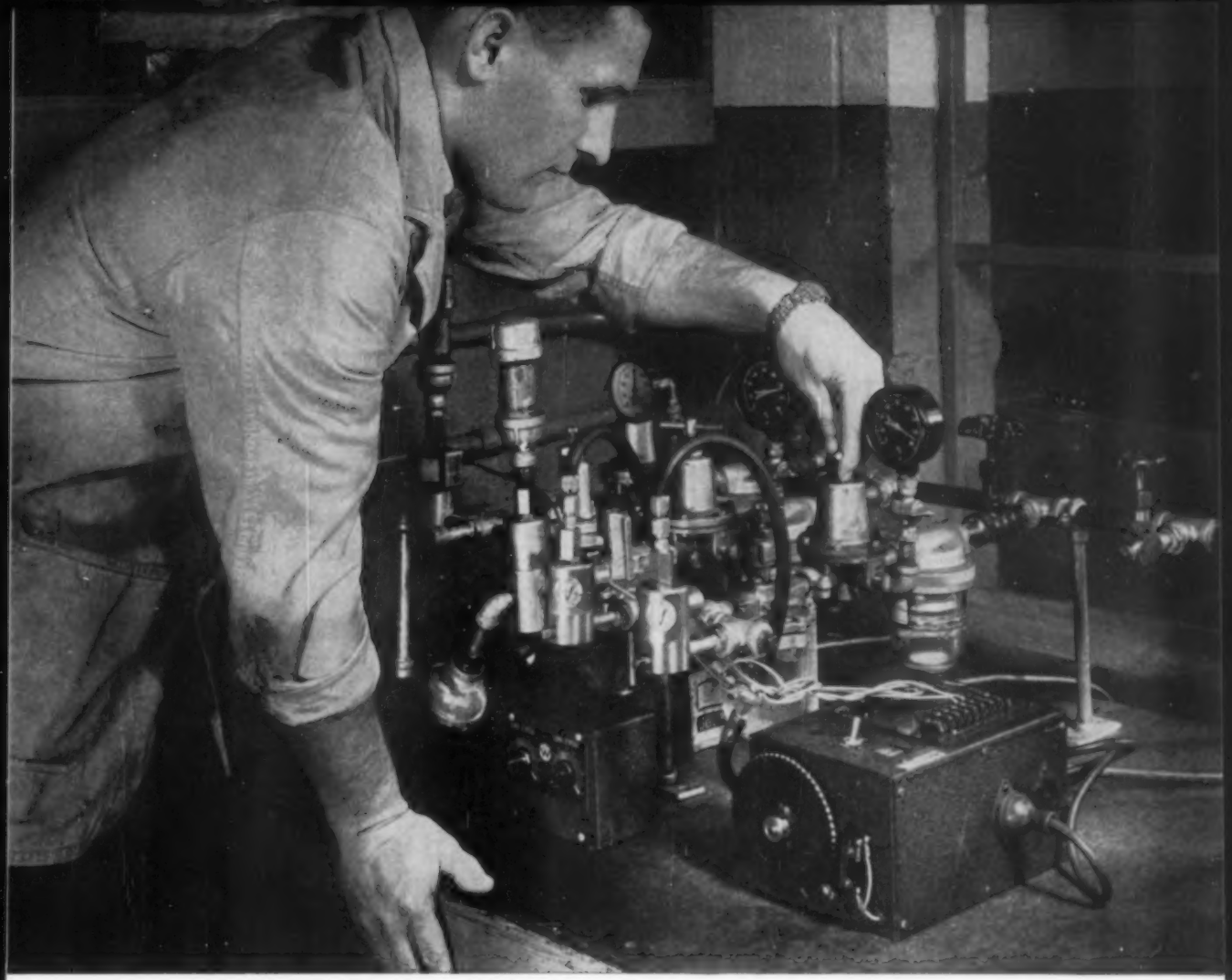

You can expect extremely long life from Skinner Solenoid Valves. Here's why...

In the lab shown above, dozens of Skinner valves are life-cycled 24 hours a day, 7 days a week, at speeds as high as 600 cycles per minute. It is here that we try out new designs, new materials, new construction methods. It is here that we test the stability of our welded joints . . . the resistance to burnout of our coils . . . the effectiveness of our positive spring returns . . . the better seal we obtain by eliminating packings. And it is here we find positive proof of Skinner valves getting over 20,000,000 cycles without leakage.

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The modern Conveyor Pulley for superior performance . . .

One tough application after another proves beyond doubt that you can't beat a lagged, Taper-Lock Steel Conveyor Pulley for the hard jobs! Here is the score on their use in rugged coke plant service. In this particular case the installation was on belts from the quencher and loading belts to cars. The report was made after *three years of use.*

1. **One-third saving on initial cost.**
2. **Saving on maintenance; no redressing of pulley faces.**
3. **No appreciable wear on lagging.**

In addition, these Taper-Lock Steel Conveyor Pulleys provide the further benefits which are inherent in their design:

1. **No bolts to shear.**
2. **Easy on — easy off.**

Taper-Lock Steel Conveyor Pulleys have terrific impact capability. All welds are made by the submerged arc process for 100% strength. Taper-Lock's patented back-up bar permits a weld of the full rim thickness to give 100% penetration. And there are no bolts to give way!

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tangents...

THE INQUIRING MIND

Today's civilization, particularly in America, is built upon scientific method—a process of combining known facts to produce a theory which in turn suggests a fairly exact direction for further research. In contrast to empirical method—the cut-and-try that characterized all earlier civilizations—the scientific method utilizes empirical data merely to confirm theory. As a result of this basic difference, the mechanical phases of our civilization are advancing by leaps and bounds, and the common man has more material things, relatively, than he has ever had before. What's more, his work is less demanding physically, he has more leisure time, and for the first time can indulge in the arts. As the product of a mechanical civilization, he has more culture, more good living, more comforts at his fingertips than the rich man of earlier civilizations. Art and culture, learning and pleasure, leisure and knowledge—these are no longer for the few, but are available to the many.

There are those who say that science has existed in earlier civilizations—even those who believe that the scientific method dates back as far as the Greeks—but there is little actual evidence to support this. Undoubtedly, the major reason that our civilization has progressed so much farther in science than any earlier one is because we have made it a mechanistic or mechanical one, perhaps largely because we have been able to develop the tools with which to produce mechanical things.

Why is this so? We have certainly had no corner on genius, nor have we demonstrated any exceptional mental skill. The exceptional thing is our organization of earlier knowledge and skills, plus our own, into a working scientific whole. For the first time in history, *all* of the sciences are being allowed to progress as fast as they will; many, in fact, are being pushed. In those areas in which genius or high interest does not exist, it is being encouraged in every possible way. For the first time, we have been able to organize facts and learn something from them. Jeans once said that a heap of unorganized facts is no more a science than a heap of bricks is a house. Modern thinkers have also pointed out that information can be highly organized, and yet certainly not scientific (as for example in music, theology, most of the arts). No one is prouder of being unscientific than, say, a classical Chinese scholar or a modern English professor.

A quick look at earlier civilizations shows, again and again, the development of fact, but the lack of organization, that precludes the development of scientific method. Babylonians, for example, first tabulated the stellar and planetary motions, and they had a good working knowledge of simple mathematics. But the achievement was only astrology. The Chinese developed gunpowder, magnetism, and were an early cultural center, but became so enamored with the tricks that could be done with these things that no science was evolved from them. The Chinese developed the tortoise-shell frames for eyeglasses to make their mandarins look intelligent; it remained for Ben Franklin to put a lens in the frame.

Ancient Egypt developed the beginnings of astronomy, produced the ancestor to the steam turbine, wove finer linen than we can weave, built structures so perfectly oriented with certain stars that modern instruments can detect no error. But the best minds of Egypt produced only gadgets for creating "spectaculars" in temples.

The Greeks were the fathers of architecture and of plumbing, but their best minds were directed toward politics or philosophy. Archimedes of Syracuse, the first real geometrician, for example, lived after political catastrophes had ruined Greece. When Rome besieged Syracuse, he designed successful war engines, but the Romans killed him when they overran the city. He had mathematics and the ability to make gadgets, but he couldn't combine the two.

The Romans took Greek architecture and other ideas from the countries they conquered. They built roads, aqueducts, amphitheaters, and a

(Continued on page 30)

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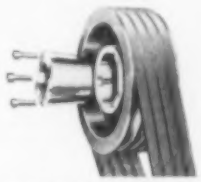

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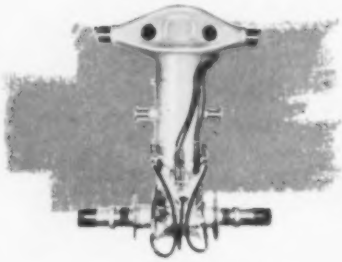
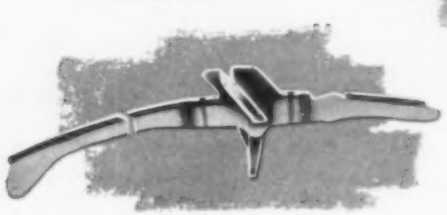
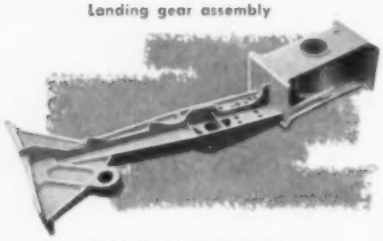


Landing gear assembly



Inboard strut for airframe assembly



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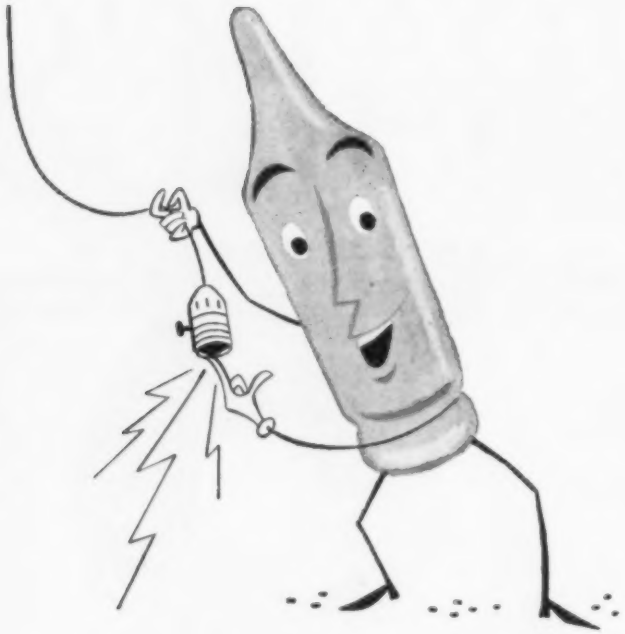

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civilization that lasted one thousand years, but they evolved no science. Genghis Khan captured all of Asia and was indirectly responsible for the tremendous Indian civilization. Again—no science. Tamerlane made of Samarkand, his capital city, a center of culture and the arts by the simple expedient of bringing back the best minds and the best skills from the cities he captured. He worked on such a mighty scale that he overwhelmed a crusade with one of his summer raiding parties, invented the method of destroying slums by putting new avenues through them, and actually decided not to bother raiding Europe because there were not spoils enough there to justify the effort. But Samarkand has long since fallen into dust, and Tamerlane's ideas with them.

All through history, we have had the evidences of the accumulation of fact and knowledge. Much of it was discarded, or disregarded by later generations. Until now, nobody has combined the facts into scientific method; most discoveries have been empirical or fortunate happenstances. Perhaps the greatest of the imperial Arab scientists was Alhazen of Cairo, who died in 1038. He was a geometrician and physicist. He knew astronomy, had the benefit of Greek civilization through Byzantium, had the tremendous advantage of the decimal system . . . but his work sparkplugged the European Renaissance, rather than sparking anything in the Arab world.

Leonardo da Vinci was trained as

(Continued on page 354)

"Watch this guy's graceful footwork—"

Why you shouldn't mail blueprints

DOESN'T PAY to mail a bundle of blueprints when a few Kodagraph Autopositive Paper intermediates will serve your purpose so much better.

Besides giving you big savings on postage, these photographic "duplicate tracings" *eliminate:* (1) home-office guesswork as to how many prints a branch or subcontractor will need; (2) tie-ups caused by a short supply of prints; (3) waste and "file stuffing" resulting from an oversupply.

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NEWS FROM FLEXONICS

BELLOWS RESEARCH AND DEVELOPMENT

One of a series of reports on more effective use of metallic bellows in new or unusual applications.

MATCHED EFFECTIVE AREA

New Flexonics technique provides bellows with effective areas matched to within 2% on a production basis

One of the problems of pressure sensitive bellows actuated devices is compensation for changes in atmospheric pressure. Flexonics Corporation has solved this problem with assemblies of bellows of matched effective area.

As indicated in Figure 1, the twin bellows are opposed mounted in a frame. The motor bellows is connected to the fluid system in which pressure is to be measured or controlled. However, this bellows is also affected by changes in external or atmospheric pressure. The compensating bellows, being sealed and completely evacuated is affected solely by the same changes in atmospheric pressure.

By joining the bellows and mounting them in a restraining frame, changes in atmospheric pressure will cause the motion of the two bellows to oppose one another. In the case of reduced atmospheric pressure, for example, the extension caused in the motor bellows is offset by the extension of the compensating bellows thereby maintaining a constant control point.

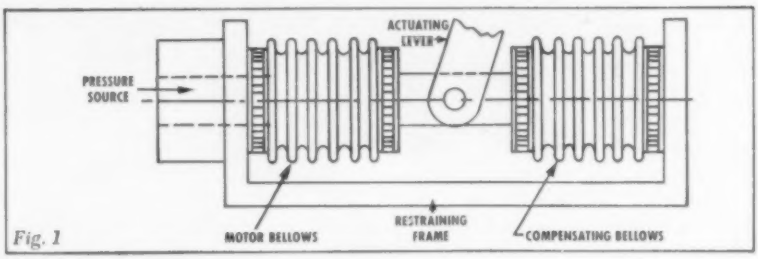


Fig. 1

Since force equals pressure times the effective area of the bellows, it is obvious that the secret of successful compensation is based on close matching of bellows effective areas. At Flexonics, effective areas are matched to within 2% in actual production. Spring rate is also closely controlled.

Such balanced performance is necessary for precision control of fuels, gases, air, pressure differentials, mixture of elements or ingredients and multiple recording devices under varying environmental conditions. Linkage may be achieved in a variety of ways to operate valves, rheostats, switches, dial indicators, needle jets or weights.

Further information is available on request. Send an outline of your requirements.

BELLOWS REPLACES CLUTCH

Unique application of Flexon Bellows in flow control valve serves to vary compressor load as demand changes

A bellows operated valve made by John E. Mitchell Co., Dallas, Texas, manufacturers of Mark IV automobile air conditioners, serves to replace a clutch that is required in other conditioners. The purpose of the clutch is to engage and disengage the compressor according to demand on the system and varying engine speed.

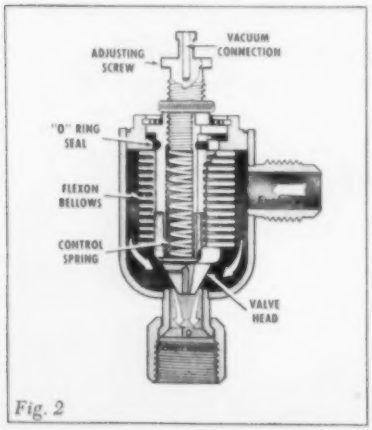


Fig. 2

Varying engine speed results in varying compressor speed and consequently in varying refrigeration effect. The Mitchell bellows-operated Robo-Trol valve compensates for the speed variations by controlling the rate of flow of refrigerant.

The interior of the bellows is connected to manifold vacuum. Thus the internal bellows pressure is higher at high speeds than at low speeds. Refrigerant at suction side pressure exerts force on the exterior of the bellows. The resultant pressure differential, directly related to engine (and compressor) speed governs the degree of opening of the valve.

Varying system demand is reflected in varying suction side pressure (the greater the demand, the higher the pressure) so the valve also adjusts flow in response to the requirements of the system.

Here is another good example of how Flexon Bellows can be used to do a control job more efficiently and more effectively. If your design requires pressure or thermostatic actuation or control investigate the advantages of Flexon Bellows or Bellows Assemblies. Just send an outline of your requirements.

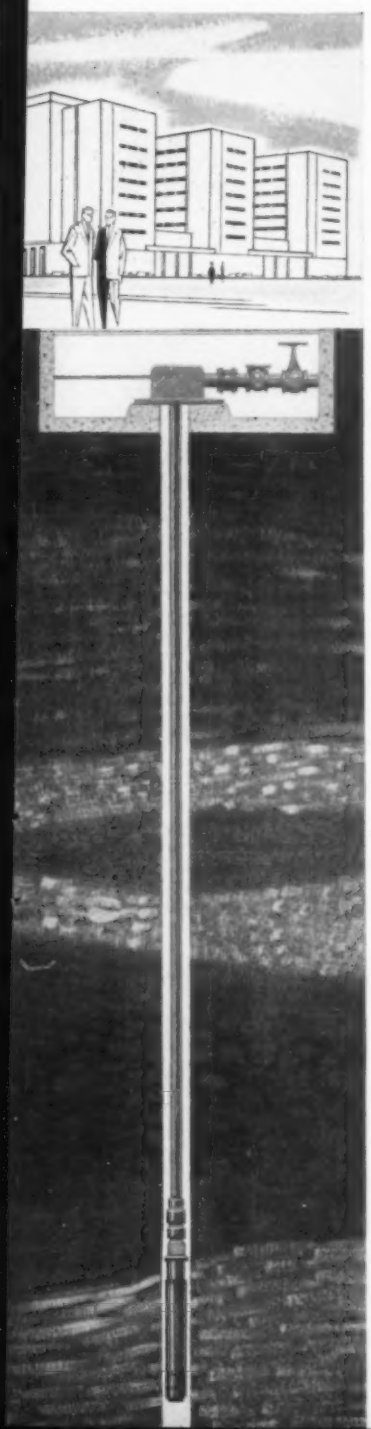
Flexonics *Corporation* — BELLOWS DIVISION

1351 S. THIRD AVENUE • MAYWOOD, ILLINOIS

In Canada: Flexonics Corporation of Canada, Limited, Brampton, Ontario

Also Manufacturers of Rubber and Metal Hose Assemblies • Expansion Joints • Aircraft Components

Now you can bury your pumping problems



FAIRBANKS-MORSE
Water-Lubricated Submersible Pump

Now you can have all the advantages of a submersible pump, plus time- and performance-tested Fairbanks-Morse features.

Fairbanks-Morse submersible pumps permit well location anywhere that a well can be drilled. No unsightly installations, no costly pump housing. Nothing—absolutely nothing—need show above ground. These pumps submerged in the well below water level are practically soundless and require no line shafts, packing boxes or lubrication devices. Hence, wearing parts needing maintenance are reduced to a minimum. A single moving assembly does all the work.

Installation is faster and more economical. The Fairbanks-Morse motor, with lifetime Copperspun rotor cooled by water and lubricated by water, gives full motor output. The well-known Fairbanks-Morse or Pomona pump bowls are combined with these wet stator motors to produce unbeatable pumping units covering a wide range of requirements as to volume, pressure, and setting depth.

For industry or community service you can place your water service trust in the F-M submersible. Contact your Fairbanks-Morse Sales Engineer and ask him for Bulletin 6910 on this time-proved submersible pump, or write today to Fairbanks, Morse & Co., Dept. PE-7, 600 S. Michigan Avenue, Chicago 5, Illinois.

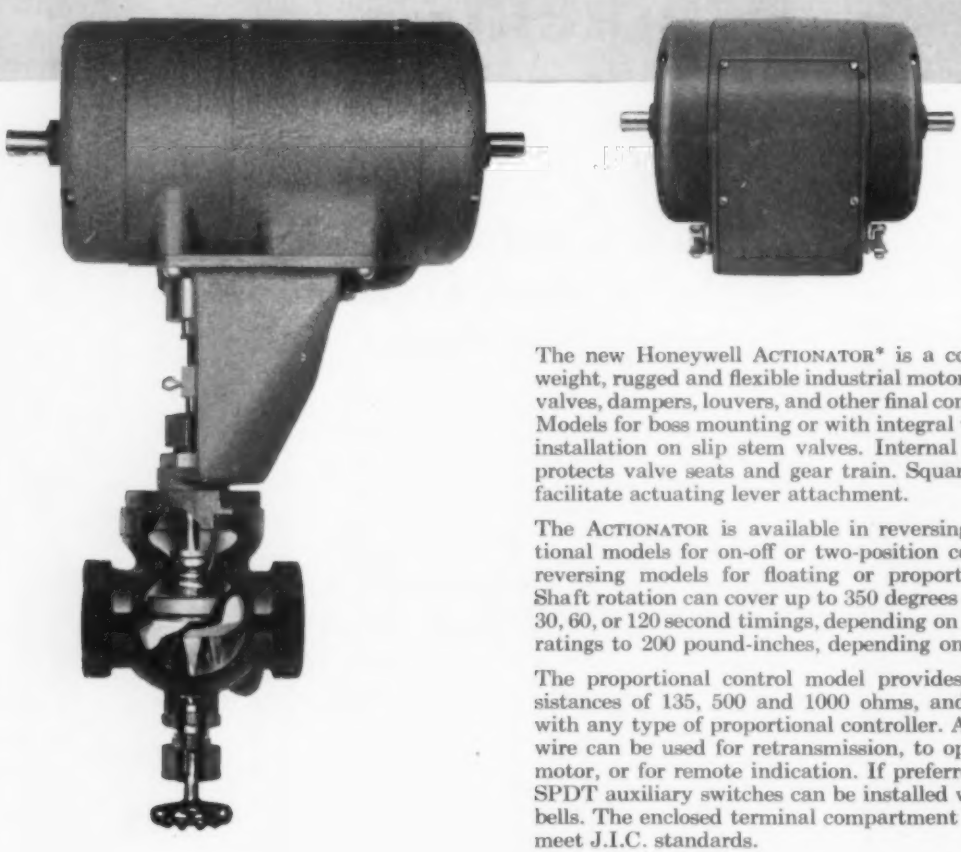
FAIRBANKS-MORSE

a name worth remembering when you want the BEST

PUMPS • SCALES • DIESEL LOCOMOTIVES AND ENGINES • ELECTRICAL MACHINERY
RAIL CARS • HOME WATER SERVICE EQUIPMENT • MOWERS • MAGNETOS

NEW ACTIONATOR*

heavy duty electric motor for operating valves, dampers, louvers



The new Honeywell ACTIONATOR* is a compact, lightweight, rugged and flexible industrial motor for operating valves, dampers, louvers, and other final control elements. Models for boss mounting or with integral valve yoke for installation on slip stem valves. Internal strain release protects valve seats and gear train. Squared shaft ends facilitate actuating lever attachment.

The ACTIONATOR is available in reversing or unidirectional models for on-off or two-position control, and in reversing models for floating or proportional control. Shaft rotation can cover up to 350 degrees in 7½, 10, 15, 30, 60, or 120 second timings, depending on model; torque ratings to 200 pound-inches, depending on motor speed.

The proportional control model provides slidewire resistances of 135, 500 and 1000 ohms, and can be used with any type of proportional controller. A second slidewire can be used for retransmission, to operate another motor, or for remote indication. If preferred, SPST and SPDT auxiliary switches can be installed within the end bells. The enclosed terminal compartment is designed to meet J.I.C. standards.

Specially designed MICRO SWITCH switches allow the ACTIONATOR to be used where ambient temperatures range from 25 to 150 F.

For complete information and specifications on the new ACTIONATOR, call the nearest Honeywell office, or write (send coupon) to:

MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, Wayne and Windrim Avenues, Phila. 44, Pa.

Industrial Division
MINNEAPOLIS-HONEYWELL REGULATOR CO.
Wayne and Windrim Avenues, Philadelphia 44, Pa.

☐ Please send me additional information on the ACTIONATOR.

☐ I'd like a Honeywell sales engineer to discuss applications of the ACTIONATOR in my plant.

Name_____

Title_____

Company_____

Address_____

MINNEAPOLIS **Honeywell**

First in Controls

*Tradename Minneapolis-Honeywell Regulator Co.

a painter, but was the genius who could design war engines, fortresses, waterworks, airplanes and submarines. He knew about the circulation of the blood, studied the weather, natural forces, and geography. But his greatest effort was expended as an artist, sculptor and director of court pageants —the potential scientist was lost.

Both of these men, as well as Archimedes, are examples of brilliant minds, directed away from science by the conditions of their immediate society. There are other examples. Tycho Brahe was a Danish noble who studied astronomy for thirty years. He made meticulous observations that were utilized by his last pupil, Kepler, to confirm the Copernican theory. But Brahe himself developed nothing from his researches. Gottfried von Leibniz invented calculus and the calculating machine, studied all sorts of things from navigation to optics, but wasted forty years of his life writing the history of the House of Brunswick. Here are genius-level minds, mis-directed.

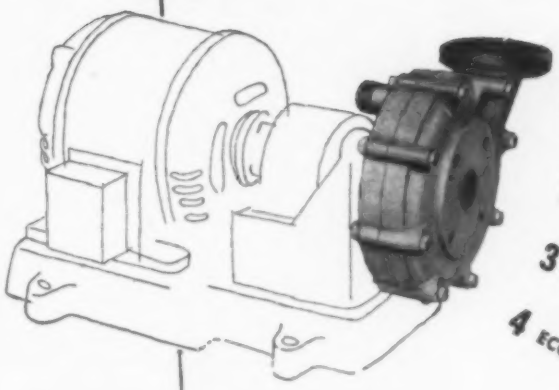
Dozens of other men might be named—men who were on the threshold of scientific discovery, but who were deflected either by themselves or by their immediate society. Their inquiring minds, which might have given us recent discoveries hundreds of years earlier, were directed away from technology. Their societies were not yet ready for them.

Today, the inquiring mind is directed—almost forced—into technology. Society is eager for more, because, viewed objectively, technology has been good to us, and for us.

—E. J. T.

"We had a beauty contest in this department last year, but nobody won."

only 1 material has all 4



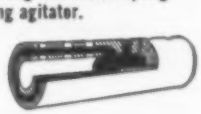
...for ACID PUMPS for instance

One of the strongest plastics known . . . .Ace Hard Rubber . . . got the nod for the impeller and casings of this acid pump. Why? (1) It's resistant to almost all corrosives; (2) High strength and abrasion resistance; (3) Won't warp or swell; and (4) Costs much less than corrosion-resistant alloys. Typical result: On one job this hard rubber pump handles 12% hydrofluoric acid, turns on and off twice a minute, 24 hours a day, six days a week . . . a mighty tough test for corrosion-resistant materials?

Many other Ace hard rubber compounds are available . . . tensiles as high as 10,000 psi, moisture absorption as low as 0.04%, power factor as low as 0.006, heat resistance to 300 Deg. F. . . . also many new plastics and rubber-resin blends. All Ace compounds are tailor-made to fit the job . . . never *over*-designed. That's why Ace is the *only* material that meets all four big requirements for parts like acid pumps.

and here's a 5th

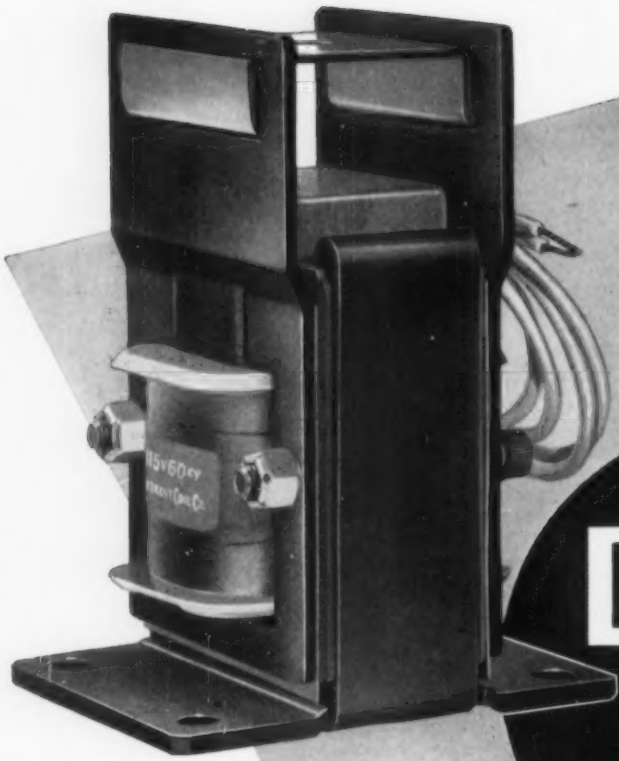
Hard rubber sleeve provides electrical insulation as well as mechanical and chemical strength in this coupling for electroplating agitator.



80-pg. Ace handbook free to design engineers.

ACE® rubber and plastic products

AMERICAN HARD RUBBER COMPANY
93 WORTH STREET • NEW YORK 13, N. Y.



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- Full one inch stroke available.
- Decco shock-mounted for long life.
- High efficiency—silicon steel laminations.
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- Shock absorbing bumpers cushion stroke.

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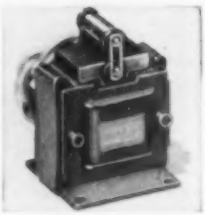
SERIES 50

INDUSTRIAL SOLENOIDS

Your choice of mounts



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There is a Decco solenoid for every requirement. Built to give better service for a longer time. Solenoids engineered and modified to your requirements. Let us discuss your problems.

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Decco SOLENOIDS THE HEART OF DEPENDABLE AUTOMATION EQUIPMENT

DETROIT COIL COMPANY

2435 HILTON ROAD, FERNDALE 20, MICHIGAN

FROM SPECS TO PROTOTYPES---FAST

Globe Industries makes to special order all of the miniature motorized devices shown on this page. But so do a lot of other companies. The difference lies in your design freedom.

At Globe you can set the specs and get prototypes in a few weeks. Our special order department builds these under the direction of the engineering department. And production orders are delivered in a few months because Globe maintains enormous inventories around which most custom designs are based.

Globe's broad base of standard parts has helped earn a reputation for earliest prototype delivery, fast production, reasonable price, aircraft standards, and repeat-business quality. Parts for your servo, timing, control, power, or air moving systems may be in Globe's inventory now. MIL specs and special development (including temperatures to +500° F.) are routine at Globe Industries.

Catalog sent to qualified firms; please request it on your letterhead. **Inquire now about products which interest you.** Get a Globe proposal on your next design.

1. GEAR REDUCED MOTORS

6 basic AC and DC motors, 2 basic gear types with 112 odd and even ratios, as well as various brakes, clutches, shafts, governors, windings and mountings. Above unit powered by SS motor. Inventoried parts for SS motors can be combined in 6×10^{17} different ways.

2. RATE GYROS

5-10 cps. is natural frequency. Provides adjustable damping and control contacts, withstands 60Gs for 11 milliseconds repeatedly. Above unit powered by MM motor. Inventoried parts for MM motors can be combined in 10^{16} different ways.

3. TIMERS

AC or DC operated timing cycles to order, from a few seconds to many minutes, adjustable or non-adjustable, multiple switching actions. Can be powered by any motor, such as the LL. Inventoried parts for LL motors can be combined in 8×10^{17} different ways.

4. CENTRIFUGAL BLOWERS

Many standard models with typical air delivery of 22 cfm. at 1" back pressure. Unit above is SC. Inventoried parts for SC motors can be combined in 10^5 different ways.

5. AXIAL BLOWERS

Many standard models with typical air delivery to 58 cfm. in above configuration and over 300 cfm. with open axial fan. Above unit powered by MC motor. Inventoried parts for MC motors can be combined in 12×10^6 different ways.

6. ACTUATORS

3 standard models around which custom units are designed, with intermittent torques up to 2500 oz. in. Above unit powered by FC motor. Inventoried parts for FC motors can be combined in 10^5 different ways.

GLOBE

GLOBE INDUSTRIES, INC.
Dayton 4, Ohio • Phone: HEmlock 3741

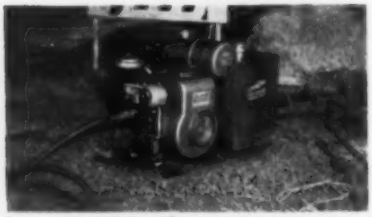
Onan
ELECTRIC PLANTS
AIR COOLED ENGINE
NEWS

New hydraulic unit pushes pipe with bulls-eye accuracy

On this job, electrical conduit is being pushed under an arterial highway, avoiding expensive trenching. The hydraulic unit, built by Mercury Hydraulics of Denver, can push pipe with amazing accuracy. On a difficult job, this unit pushed 2-inch conduit 186 feet with less than 8 inches deviation from the sighted line!

The hydraulic unit is driven by an Onan 5.5 H.P. "AJ" engine. This Onan model was selected because of its smoother running and many long wearing features such as extra-large bearing surfaces.

Onan engines deliver more horsepower hours per dollar, *step-up performance of power equipment.* **Gasoline models: 1-cyl. 5.5 H.P., 2-cyl. 12.9 H.P., 2-cyl. Diesel, 15 H.P.**



Power unit, including Onan engine, reservoir and pump are mounted on skid. Hose leads from pump to hydraulic pusher in the excavation.

Call Minneapolis FE: 2-1155

Onan ELECTRIC PLANTS

Write for specifications

D.W. ONAN & SONS INC.

3827 University Avenue S.E.
Minneapolis 14, Minnesota

DESIGN ABSTRACTS

Fatigue and Internal Friction of Aluminum

Investigation of the internal friction and fatique strength of commercially pure 1100 aluminum under repeated stressing in torsion at various temperatures and stress levels indicated the existence of a critical temperature at which the fatigue life of the specimens reaches a minimum value. The effect of this temperature on the internal friction at various stress levels was substantial. Recovery of internal friction was observed to depend upon the stress level and temperature of testing.

Abstracted from "Fatigue and Internal Friction of Aluminum," by S. R. Valluri, California Institute of Technology, National Advisory Committee for Aeronautics Technical Note 3755, September 1956.

Gear Drives for Extreme Conditions

An understanding of the variables that enter into gear operation is essential if a sound background for gear design is to be established. Not only the variables involved but their interaction, must be taken into account if optimum operation is to be achieved.

Elastic deformation and errors in form and spacing cause two variations in the load on gear teeth at each tooth engagement. As the load is transferred from the driving gear to the driven gear fluctuating dynamic loads are encountered.

The first variation in the dynamic load is caused by accelerations produced as the driven member is pushed ahead while the driving member is retarded. When the errors in form have been compensated for by these accelerations, the driving member is moving slower and the driven member is moving faster. This relative change in speed tends to separate the contacting surfaces but input power and elastic windup of the system eventually bring the two surfaces into an elastic impact. This second, and more important, variation in the dynamic load is usually of higher intensity because the change in acceleration is absorbed in a much shorter internal of time.

The value of the acceleration depends upon the conditions of engagement of the teeth and the square of the pitch line velocity. The value for the conditions of engagement depend upon the pressure angle of the gears and their diameters. This applies to gears with straight teeth. When helical gears are involved, then the influence of the helix angle must also be included.

The bodies involved are elastic and at infinite speeds there is not enough time to disturb the velocities of the rotating masses. Therefore, the influence of the errors would be restricted to deformation equal to the amount of the effective error. This results in an asymptotic load which represents the maximum possible value of the dynamic load. In actual operation, the teeth deflect under the acceleration load, reducing the intensity of the actual acceleration load. This leads to the relationship:

f_1 = value of the first phase, reactions of rigid bodies
f_2 = load required to deform teeth amount of error
f_a = resultant acceleration load

Then

$$\frac{1}{f_1}+\frac{1}{f_2}=\frac{1}{f_a} \text{ or } f_a=\frac{f_1 \times f_2}{f_1+f_2}$$

At the instant of maximum impact, when both systems are again moving at the average speed, some of the energy is kinetic and some, stored in the elastically deformed tooth surfaces, is potential. The maximum deformation at impact also includes the deformation caused by the transmitted load. By equating these energy conditions to each other, we get an equation for the intensity of the elastic impact or dynamic load, as follows:

When W = transmitted tooth load
Wd = dynamic load
k = maximum amount of separation
d = elastic deformation of teeth under load W.

$$W_d = W\left(1+\sqrt{1+\frac{2k}{d}}\right)$$

The foregoing is a general equation

(Continued on page 362)

TAYLOR Laminated Plastics Vulcanized Fibre

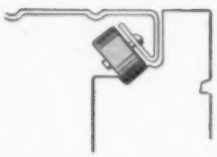
Shop Talk

TAYLOR FIBRE CO.

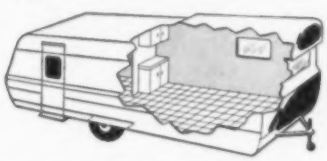
Plants in Norristown, Pa. and La Verne, Calif.

PHENOLIC—MELAMINE—SILICONE—EPOXY LAMINATES • COMBINATION LAMINATES • COPPER-CLAD LAMINATES • VULCANIZED FIBRE

Tips for designers

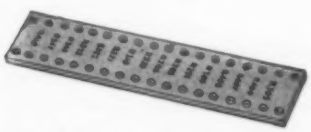


Rollers for sliding drainboards of double drain sinks are made of Taylor Grade L phenolic laminate, have high impact strength and resistance to wear.



House trailer interior walls are made of plywood faced with Taylor vulcanized fibre, chosen for its combination of light weight and high strength.

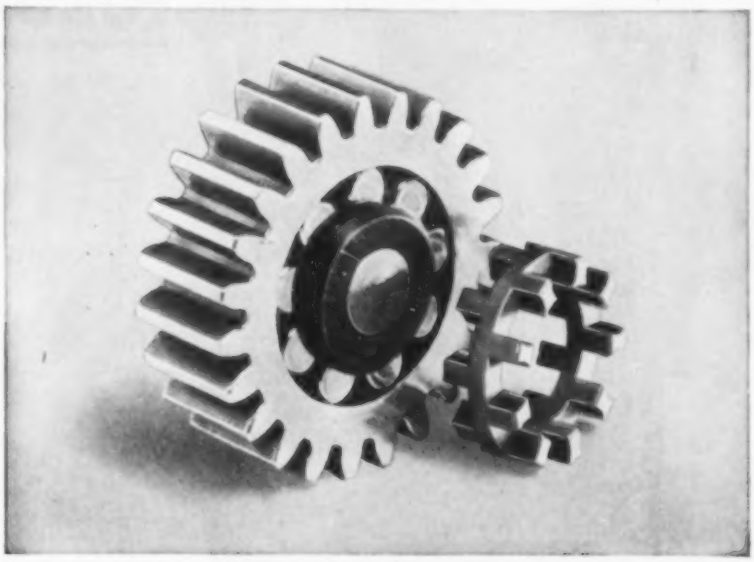
Fan blades can be fabricated from Taylor Grade C-7 post-forming laminate . . . have excellent physical strength and operate quietly.



Terminal strips for high-precision electronic instruments benefit from the excellent insulating properties of Taylor XXXP-301 hot-punch laminate.

TAYLOR SUPERIOR COPPER-CLAD LAMINATES

Taylor GEC (glass epoxy) Copper-Clad and Taylor XXXP-242 cold punching (paper-phenolic) Copper-Clad. Taylor uses high purity rolled copper on base materials with outstanding electrical properties.



Roller bearing cage, used by Steel Products Engineering Co., division of Kelsey-Hayes Wheel Co., is fabricated to very close tolerance by Taylor . . . of Grade L phenolic resin. This material provides good machined edges, wearing qualities and impact-fatigue strength.

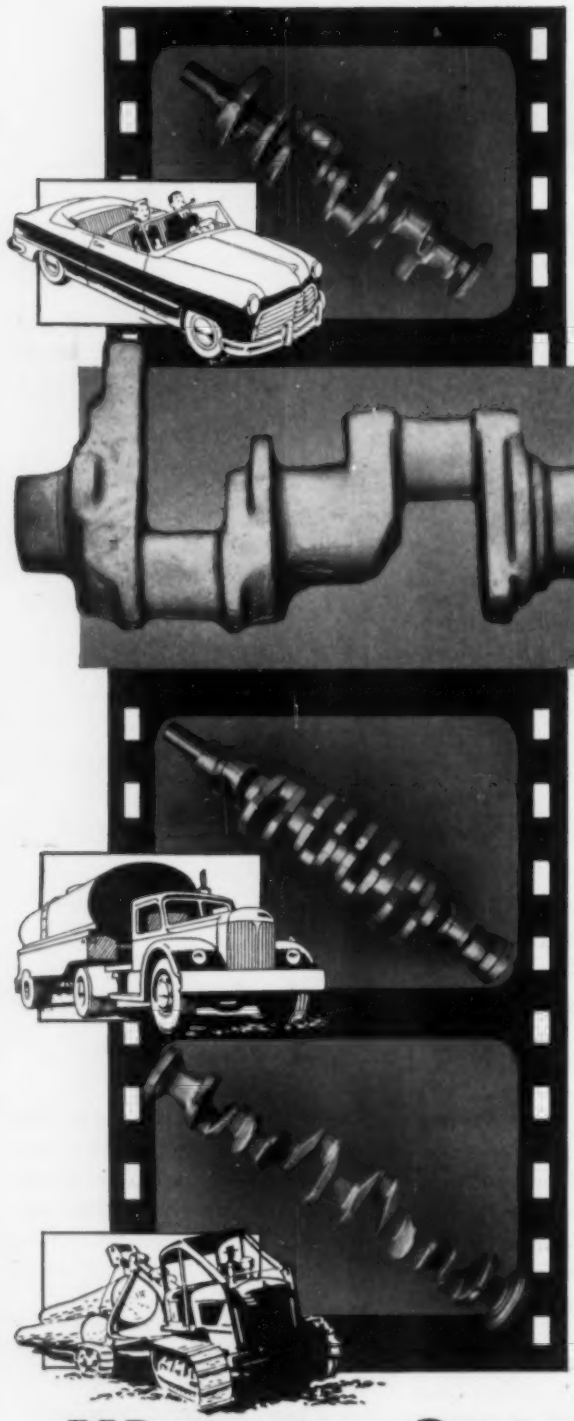
Need accurate laminated plastic parts? Taylor can do the job for you.

This roller bearing cage posed a problem in both material selection and fabrication. It had to have high impact-fatigue strength and good wearing qualities, and it had to have edges and inside diameter machined to extremely close tolerances. Taylor Grade L phenolic tubing proved to be the right material, and Taylor's Fabrication Division solved the production problem.

Many manufacturers have found the answer to their fabrication and assembly difficulties with the help of this Taylor facility, by having parts supplied completely fabricated to specified tolerances, ready for final assembly. With specialized equipment and advanced techniques, Taylor is prepared to simplify production problems, safeguard delivery schedules, and eliminate inventory headaches.

Chances are that you have a product design job on hand right now that Taylor can produce to the close tolerances you need. And Taylor can deliver it quickly and economically to your exact specifications.

Taylor's fabricating facilities and engineering staff are at your service. Contact your nearest Taylor sales engineer for a discussion of your particular requirements.



There's no substitute for the FORGED crankshaft

Crankshafts have been made successfully by other methods of fabrication and have proven to be *good enough* for certain non-critical applications—but for maximum dependability of the modern, compact, high compression, high torque engine a forged crankshaft is essential.

The forging process assures, to the greatest degree possible, uniformity and predictability of physical properties with a minimum variance from piece to piece or from one location to another in the same piece.

Wyman-Gordon has been forging crankshafts since the beginning of the internal combustion engine era and today produces more crankshafts for a greater variety of applications than any other company in the world. In a crankshaft there is no substitute for a forging, and in a forging there is no substitute for Wyman-Gordon quality and experience.

WYMAN-GORDON COMPANY

Established 1883

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HARVEY, ILLINOIS • DETROIT, MICHIGAN

FORGINGS OF ALUMINUM • MAGNESIUM • STEEL • TITANIUM

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U.S. Axle Shafts are custom-engineered to your specifications. Made from the finest heat-treated, alloy steels—U.S. Axles are also shot-peened to make them up to *5 times tougher!* Use the advantages of U.S. Axles to improve *your* product's performance.

Send us your blueprints and specifications for prompt quotations on your requirements.

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SHOT-PEENED to make them up to **5 TIMES TOUGHER**

VALUABLE BROCHURE *FREE*
Shows you why U.S. Axle is your best source for precision-made special shafts.

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for elastic impact when an applied load is acting on the bodies during impact. This equation is valid for static loads, suddenly applied loads, and also when there is a preload at the instant of reversal of load, or when there is a finite amount of separation between the surfaces.

In addition, factors such as high speeds, life expectancy, fatigue of metals, coefficient of friction, lubrication and alignment must be considered if nothing is to be left to chance.

Abstracted from "Design of Gear Drives for Extreme Conditions" by Professor Earle Buckingham, Technical Director, Gear Systems Inc., Boston, Mass., and T. W. Khiralla, President, Gear Systems Inc., Boston, Mass. Presented at 41st Annual Meeting of the American Gear Manufacturers Association, Hot Springs, Virginia, June 2-5, 1957.

Undercutting of Spur Gear Teeth

In the generation of spur gear teeth either by a hob or a gear shaper, it is known that when a relatively small number of teeth are cut a portion of the involute profile is removed. This is known as undercutting and adversely affects the performance of the gear. In this article the theory of complex functions is used to determine the amount of undercutting produced by a hob and also by a gear shaper.

Undercutting on a pinion, even a slight amount, greatly reduces the interval of contact for the pinion tooth and its mating gear tooth. This can result in larger loads on the teeth producing higher contact stresses and bending stresses in the teeth as well as a reduction in the smoothness of operation. In practice sufficiently accurate determinations of the extent of undercutting have been made from large scale layouts on which the intersecting involute and trochoidal curves have been generated with the aid of a template of the cutter tooth.

The treatment in this article gives a set of equations which may be solved by trial, and the analysis is extended to include the cutter of finite pitch radius (pinion type gear shaper). Buckingham ("Manual of Gear Design Section Two," Industrial Press, New York, 1935) presents an equation which he states gives an approximation to the amount of undercutting

(Continued on page 366)

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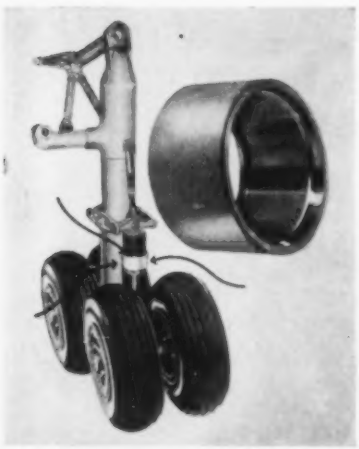

Synthane (arrow) serves as bearing in landing gear shock struts.

Synthane laminated plastics lead a busy life aloft.

In communications equipment, Synthane is found in hundreds of insulating parts. In aircraft instruments, precision ball bearing retainers and innumerable other parts Synthane is at work. The airframe itself finds Synthane at work in a number of critical applications such as landing gear struts.

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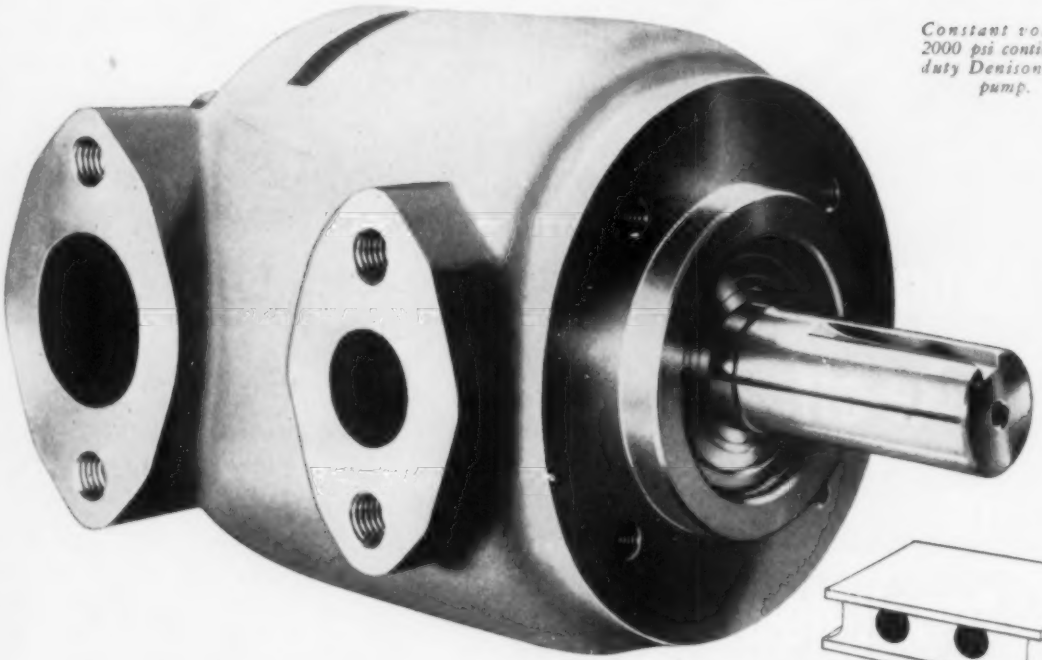


Constant volume 2000 psi continuous duty Denison vane pump.

Hydraulically balanced vane utilizes internal oil pressure to maintain constant pressure of sealing edges against cam ring.

2000 PSI VANE PUMPS

Proper Application

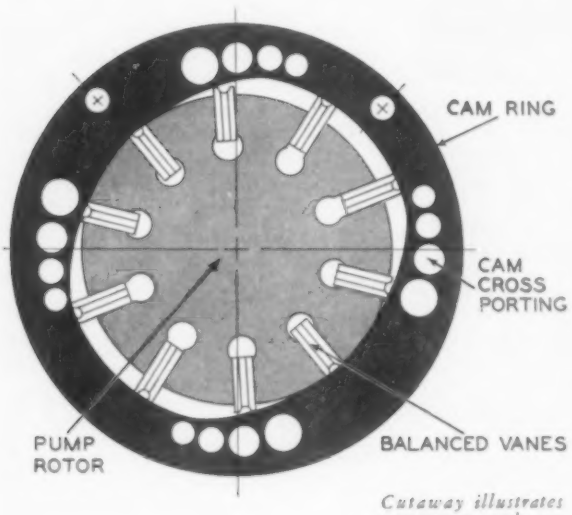
Hydraulic Performance

Operating Characteristics

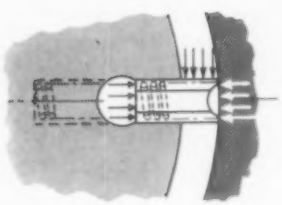
By **Ellis H. Born**
Chief Application Engineer
Denison Engineering Division
American Brake Shoe Co.
Columbus, Ohio

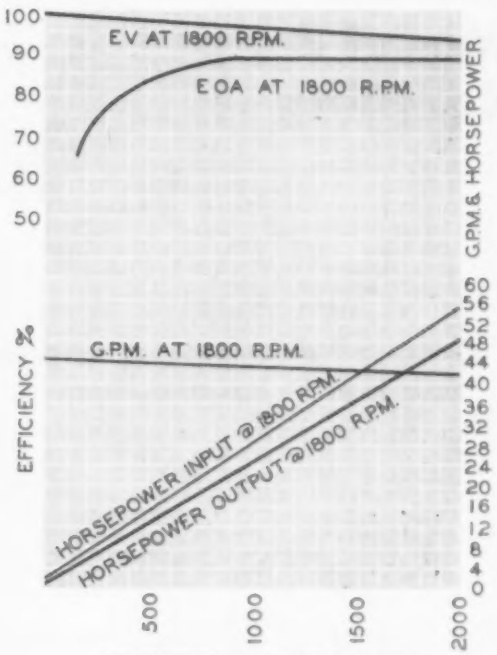
INEFFICIENCIES introduced by line loss are reduced 50% by increasing the pressure from 1000 to 2000 psi.

In designing hydraulic circuits, it is normal to limit line velocities to a maximum of from 15 to 20 feet per second, permitting the use of the smallest practical lines, valves and fittings. The pressure drop in transmitting the fluid medium is thus dependent on flow velocity, number of valves and fittings, and line length. If, for example, the pressure drop of a given system is 50 psi, this would represent a loss in transmission of 5% for a 1000 psi system and a loss of



Cutaway illustrates pump rotor and cam ring assembly. (Below) Pressure balancing relieves hydraulic bearing loads between vanes and cam ring.





Performance Curve of 2000 psi vane type pump illustrates high volumetric efficiency attained with double seal, balanced vane construction.

2.5% for a 2000 psi system. The power lost in transmission is thus reduced 50% by using 2000 psi components.

In sizing components for the transmission of a given horsepower, an interesting comparison of component size, weight and costs can be made. For example, if a job requires the transmission of 16 horsepower, a flow of 16 GPM at 2000 psi working pressure, or 32 GPM at 1000 psi, would be required. Thirty-two GPM would require 1¼" valves, but 16 GPM only ¾" valves. The use of the higher pressure results in a great advantage in that the hydraulic system can be set up with components of lower weight, lower cost per horsepower and smaller, more easily installed pumps, motors and valves.

Additional gains in hydraulic efficiencies are realized by the fully balanced design, not only on the rotor, but on the vanes themselves. Four years of field experience shows that high volumetric efficiencies are maintained over longer periods of service. Wear on cam rings is reduced over conventional designs where the vane is held against the cam ring by hydraulic pressure.

The balanced vane is achieved by a construction allowing the vane to be open at both ends to pressure on the pressure stroke, and to suction on the suction stroke.

Specifications and application data on this vane pump, which also operates as a hydraulic motor, are available by writing.

DENISON ENGINEERING DIVISION
American Brake Shoe Company
1160 Dublin Road, Columbus 16, Ohio

REQUEST FOR APPLICATION DATA

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Please send specific data on proper application of vane pumps for my needs. Problem is _____

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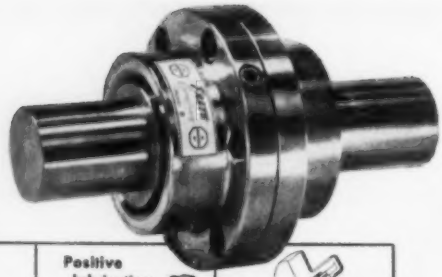

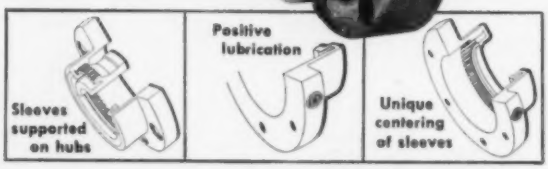

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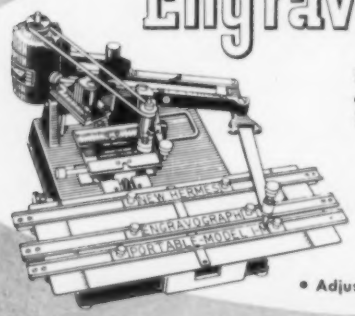

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produced by either a rack cutter or a Fellows cutter (cutter of finite pitch radius). Further, he points out that this equation gives values which are somewhat in excess of the exact values.

The equations developed in this paper for the rack form of cutter are exact and thus have been found to give values for the amount of undercutting that agree with the results obtained using the equations of Naruse and those of Spotts, both of the latter being also of exact form.

Abstracted from "Undercutting of Spur Gear Teeth," by G. H. Martin, Michigan State University, East Lansing, Michigan. The American Society of Mechanical Engineers Paper No. 57—S-3, presented at the ASME Spring Meeting, Birmingham, Alabama, April 8-10, 1957.

Aging of Some Aluminum Alloys

The most significant factor in the development of high strength properties of 75S and similar alloys lies in the effect of small magnesium additions on the aging characteristics of the aluminum-zinc binary alloys.

Main equilibrium precipitate is $MgZn_2$, but under certain conditions a number of other phases are also present. All phases probably precipitate from the solid solution through a series of intermediate states. Minor addition elements affect precipitation and properties in these alloys. Nucleation of precipitating phases by chromium is discussed.

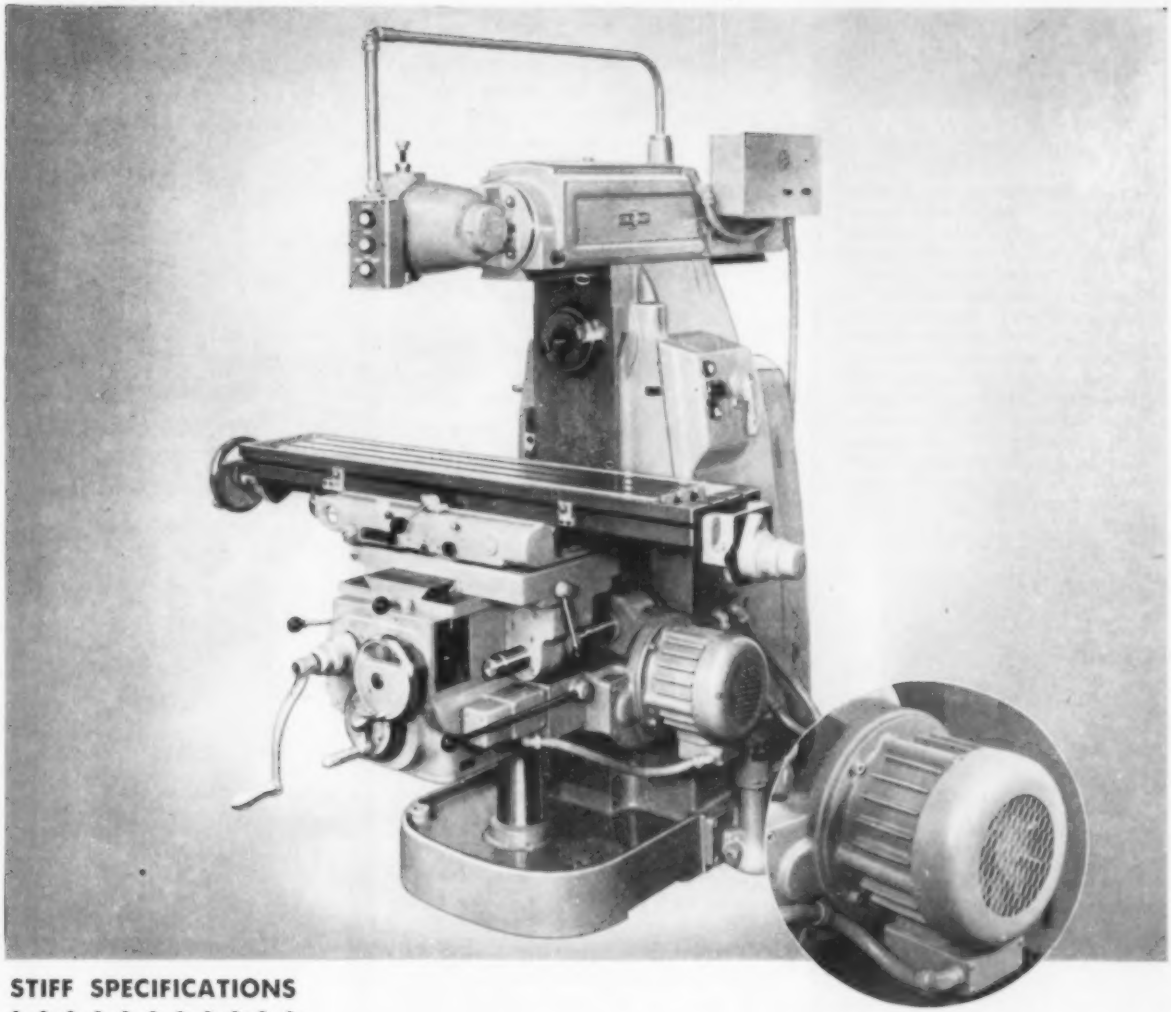
Abstracted from, "A Critical Review of the Mechanism of Aging in Alloys Based on the Aluminum-Zinc-Magnesium System," by I. J. Polmear, Department of Supply, Australian Aeronautical Research Committee, available through the National Advisory Committee for Aeronautics, 1512 H Street, NW, Washington 25, D. C., 1956.

Vacuum and Hydrogen Brazing

Vacuum and hydrogen brazing of four heat-resistant alloys were investigated, effect of time at brazing temperatures on the 1200 F shear strength of joints and on the base-metal properties was studied, and brazing techniques were evaluated.

Results showed that shear joints made with the boron-bearing braze

(Continued on page 368)



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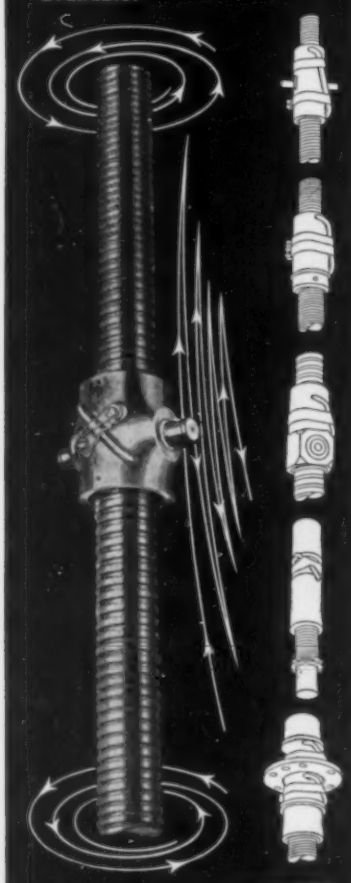

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were stronger. Higher carbon of the boron-bearing alloy may be significant.

Furnace brazing temperatures and time at temperature were important in lowering tensile strength and elongation of braze-coated sheet-metal tensile specimens. Effect varied depending on base metal and brazing alloy used.

Shear specimens exhibited erratic joint coverage by the brazing alloys. That data indicated, however, that if joint coverage was complete, vacuum and hydrogen brazing produced joint shear strengths of about the same magnitude.

Abstracted from "Vacumm and Hydrogen Brazing," by Walter E. Russell and John P. Wisner, National Advisory Committee for Aeronautics Technical Note 3932, March 1957.

On the Statistics of Individual Variations of Productivity in Research Laboratories

It is well-known that some workers in scientific research laboratories are enormously more creative than others. If the number of scientific publications is used as a measure of productivity, it is found that some individuals create new science at a rate at least fifty times greater than others.

A study of the relationship of salary to productivity shows that rewards do not keep pace with increasing production. To win a 10 per cent raise a research worker must increase his output between 30 and 50 per cent.

However, increase in scientific productivity alone is not sufficient to produce the increase in merit rating. In fact, coupled with the 30 to 50 per cent increase in productivity, there probably must be comparable increases in other kinds of contribution. In other words, the individual probably must become 30 to 50 per cent better in all respects in order to receive a recognition corresponding to a 10 per cent increase in salary.

The top salaries in government laboratories are substantially lower than those in both industry and in universities, at least for people in the latter whose line of work involves undertaking summer assignments and doing

(Continued on page 370)

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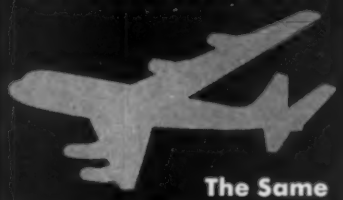

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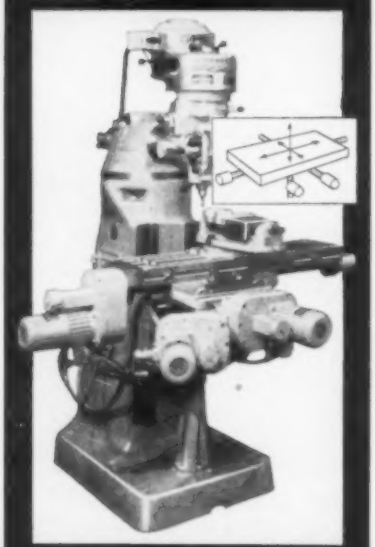

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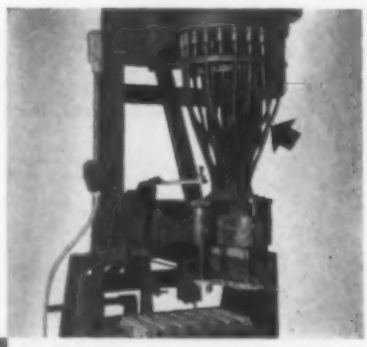

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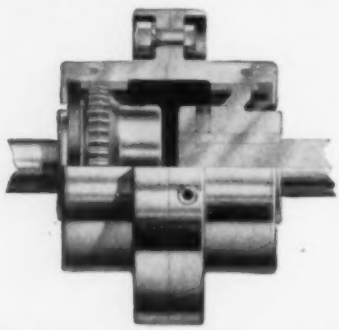

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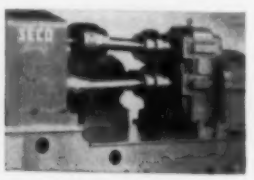
Ajax Floating Shaft Dihedral Couplings solve angular drive problems on tilting tables for the Green River Steel Corp., at Owensboro, Kentucky.



Two Ajax Dihedral Floating Shaft Couplings driving SECO 48" heavy duty slitter in operation at McLouth Steel Co., Detroit, Michigan, cutting ¼" stainless steel at 100 ft. per min. with 16" diameter knives.

AJAX FLEXIBLE COUPLING CO. INC.
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consulting. Even if there were no disadvantages aside from salary, the limits of salary set by Civil Service scales probably have a most severe effect on the leadership and originality available in government laboratories. Although these attributes have not been studied quantitatively, all of the findings in this article are consistent with the idea that leadership and originality increase very rapidly with salary just as do rate of publication and rate of invention. Cutting off the top of the salary scale at, say, $12,000 per year as compared to $18,000, will mean a reduction of productivity of 3 to 8 fold. Statistically, for the higher salaried man the return per dollar of salary is two to five times as great so far as individual productivity is concerned. If leadership qualities vary in a way similar to productivity, the return from increased salary will be enormously greater since an effective leader may substantially improve the output of many men.

In closing, I should emphasize that there are outstanding exceptions to most statistical results. Government laboratories do succeed in retaining a few outstanding individuals. These are unfortunately exceptions rather than the rule. Because of the present top limits on Civil Service salaries for scientists, the taxpayer's dollar is buying less research value than it should. A policy of having more highly paid positions might well double the return per dollar. It might also contribute significantly to offsetting the lead which the U.S.S.R. has currently gained in numbers of technical degrees granted in universities per year.

Abstracted from, "On the Statistics of Individual Variations of Productivity in Research Laboratories," by William Shockley, Proceedings of the IRE, March 1957.

Ball Fatigue

SAE 52100 standard bearing steel and AISI M-1 tool steel balls were investigated at both room temperature (80 F) and at 200 to 250 F. Fiber direction, inclusions, and chemical segregation contribute toward fatigue failures and life scatter.

Some structures stable at room temperature, were unstable when tested at 200 or 250 F, both SAE 52100 and AISI M-1 steel being sensitive to small temperature increases.

All ball fatigue failures were visually similar and usually progressed from shear cracks. Failure origins included chemical segregation, inclusions, surface pitting, and structure changes. Many incipient cracks originated at inclusions. Ball pole regions, were weaker areas in fatigue in the initial test runs. All failures were of the same type as those found in full-scale bearings.

Abstracted from "Ball Fatigue" by H. Robert Bear and Robert H. Butler, National Advisory Committee for Aeronautics Technical Note 3925, March 1957.

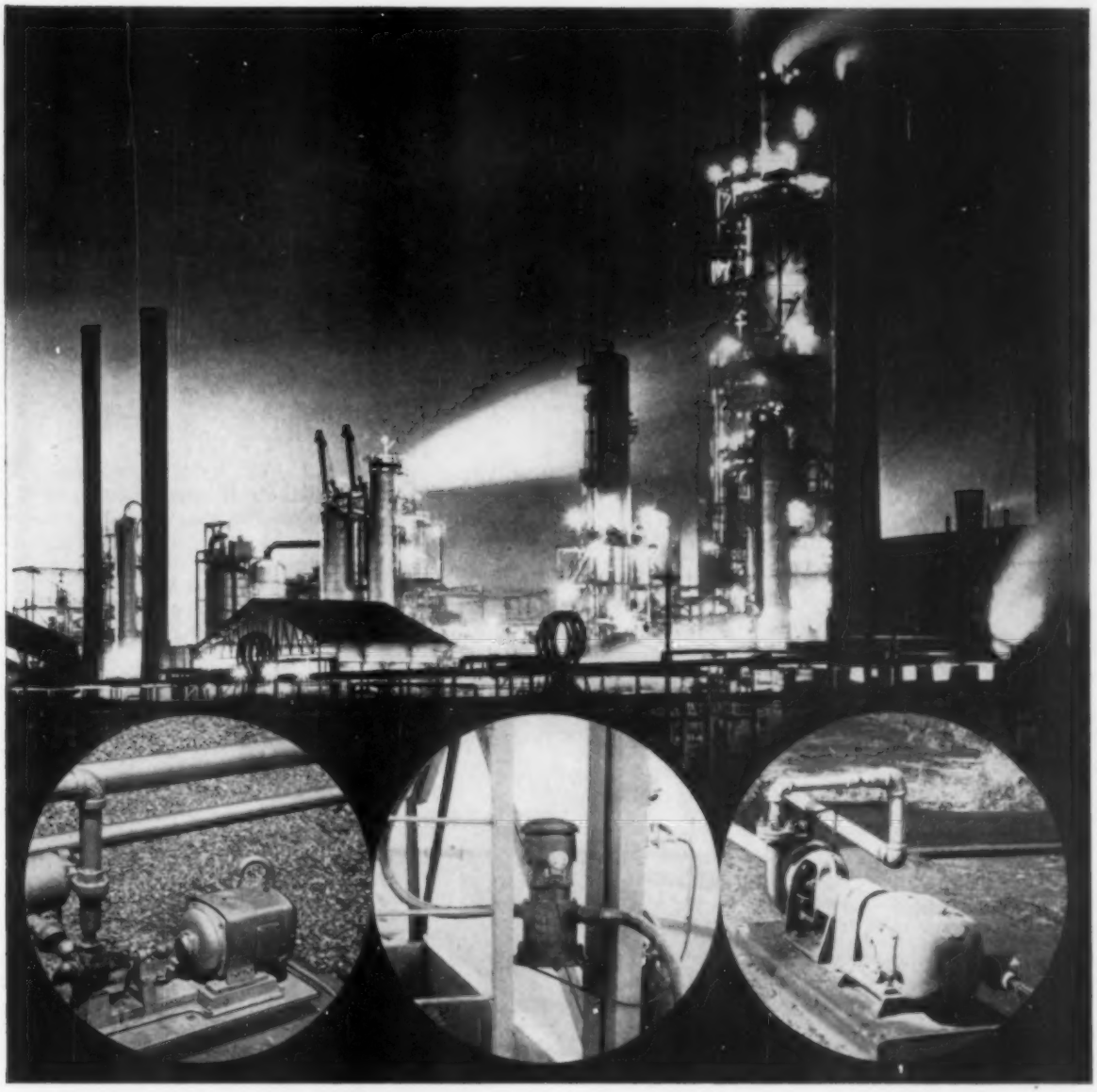
Wrought Titanium

Hardness of forged, rolled and swaged bars of commercially pure titanium, annealed for various times at 550, 650, 700 and 750 C in air and in vacuum, were compared to determine extent of oxygen contamination and suitable annealing procedures.

Annealing at 700 C for 1 hr gave an almost fully softened product even after extensive cold working. This treatment does not lead to undesirable pick-up of oxygen.

Abstracted from, "The Hardness of Wrought Titanium," by A. R. G. Brown and P. M. R. Gates, available from National Advisory Committee for Aeronautics, 1512 H Street, NW, Washington 25, D. C., July, 1956.

"I was feeling real good this morning until I woke up."



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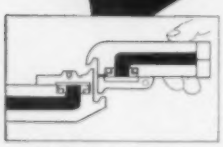
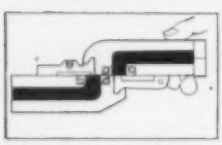
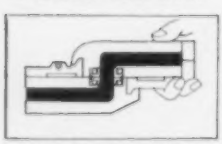


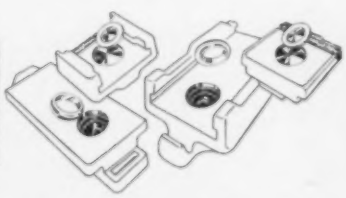
HOOK UP



PUSH-CLICK!



FREE FLOW



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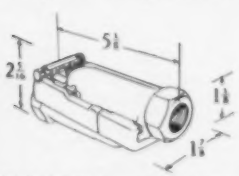
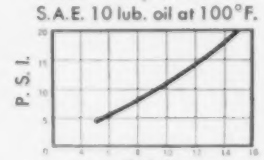


½" N.P.T. Female Both Ends

Pressure Drop vs. Oil Flow
S.A.E. 10 lub. oil at 100°F.



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Printed Circuit Electronic Assemblies

PB 121163, E. Aldred, L. Broderick, C. Everhart, M. Hinebaugh, P. R. Mallory & Co., Inc., *Indianapolis, Ind.* 8½ x 11 in., 54 pp. paper-bound. *Available from U. S. Dept. of Commerce, Office of Technical Services, Washington 25, D. C.* $2.

The purpose of this development was to establish four practical and effective systems of packaging and integrating automatically assembled card-type assemblies. The systems of packaging devised included plug-in, stacked mechanical, distributed connector, and mechanically cascaded packages.

Over 30 development test vehicles were designed, fabricated, tested, and analyzed. Package analyses pertaining to ruggedization, climatic protection, thermal adequacy, size and weight, and maintenance have been included in addition to the consideration of four systems of integration compatible with the four methods of amplifier packaging. Each system of integration is discussed with respect to rf, if, and af amplifiers. Specific design guides, principles, and techniques compatible with the "Auto-Sembly" system of fabrication are discussed in Part II. A bibliography is included.

Reinforcing High-Temperature Alloys with Refractory Powders

PB121474, J. D. Burney, *P. R. Mallory Co., for WADC.* 8½ x 10½ *in., 42 pp. Available from U. S. Dept. of Commerce, Office of Technical Services, Washington 25, D. C.* $1.25.

Possibility of reinforcing 80 nickel-20 chromium alloy by the addition of stable refractory oxides is examined in this report of research, part of a continuing project to develop an improved high-temperature material for use in jet engine guide vanes and buckets. Emphasis was placed on type, amount and particle size of the oxide

(Continued on page 375)

tells how you can save time and money with

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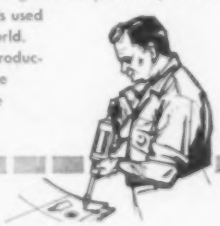

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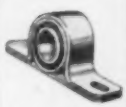

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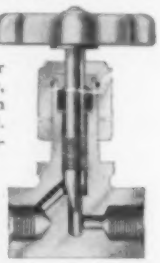

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and techniques for its proper dispersion with the base alloy. Oxides Al_2O_3, TiO_2, ZrO_2, Cr_2O_3 and SiO_2 were used. Fabrication techniques included pressing and sintering; pressing, sintering and repressing; pressing and sintering followed by hot working, hot pressing; and liquid-phase sintering. Hot forging techniques were found applicable for working bars containing oxide additions of 1.0 per cent or less.

Introduction to Nuclear Engineering

RICHARD STEPHENSON. 6¼ x 9¼ *in.*, 387 *pp. Published by McGraw-Hill Book Co., Inc.*, 330 W. 42 *St., New York 36, N. Y.* $8.

This book is intended as an introductory survey of the nuclear-energy field for engineers who are taking or who have completed a conventional engineering curriculum. It is assumed that the reader is familiar with the standard engineering operations, and only the unique features of nuclear energy are discussed. Of necessity the book contains only unclassified material, but this has not been a serious limitation, since most of the fundamental engineering principles have been released. Much of the material presented here comes from personal discussions with engineers and scientists now employed in the nuclear-energy field. Chapters are included on nuclear physics, nuclear fission, reactor theory, materials of construction, instrumentation and control.

Electrodeposited Metallic Coatings

Paper cover, 6 x 9 in., 129 pp. Published by ASTM, 1916 Race St., Philadelphia 3, Pa. $3.

Advances in the field of electroplating have broadened the use of electro-deposited metals so that now they may be found on products for the home, industry, building trade and the military. Such extensive use makes this symposium especially valuable to both producers and consumers of electro-deposited materials, as well as to the designer who initiates their use.

Functionally, electroplating is used for appearance, for corrosion resistance

(Continued on page 377)

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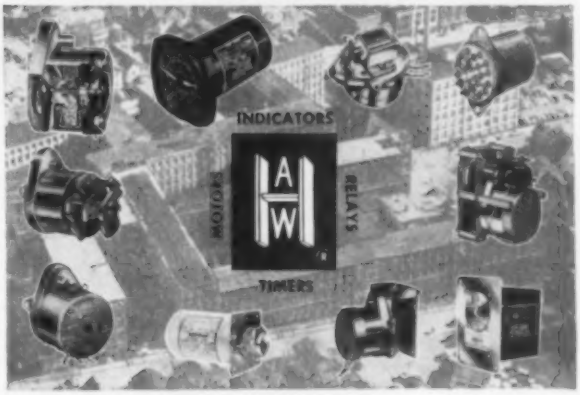

Shown below is the new catalog of the A. W. Haydon Company describing all of the basic types of units available and many of the "specials". Included in this 25-page catalog are 60 photographs of timers, 30 dimensional drawings, and 50 charts and diagrams. This complete catalog will be supplied on request.

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- . . . increased cycles from 28,000 to 700,000 in tests on brass taper air valves. (Field Report 4)
- . . . raised Oilite bearing life from 6 to 46 hours. (Field Report 24-47)
- . . . raised life to failure time from 120 to 400 hours on sintered bronze bearings; reduced wear in 12 hour test from .002 to .001. (Field Report 43)

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and for wear resistance. While appearance and corrosion resistance have been treated adequately, a discussion of the abrasion resistance characteristics of electrodeposited metallic coatings would have made the whole presentation more complete.

The volume is extensively illustrated and amply documented with comprehensive tabular data.

Survey of the Methods Used to Determine the Dynamic Mechanical Properties of Polymers

PB 121767, Oscar R. Abolafia Picatinny Arsenal, Dover, N. J., 8½ x 10½ in., 34 pp, paper-bound. Available from Office of Technical Services, United States Dept. of Commerce, Washington 25, D. C., $1.

This report is literature survey of the best methods for determining the dynamic mechanical behavior of polymers. A general theoretical treatment of the information is given by classifying the test methods so that they may be more conveniently discussed and compared. The best methods are grouped into three major divisions—attenuation methods, resonance methods, and direct stress-strain methods. Each division is further broken down into sub-groups. Brief comment on the various test methods is provided dealing with ease of operation, degree of accuracy and precision, and cost of instrumentation.

Technical Data on Plastics

8½ x 11¼ in., 213 pp. Published by Manufacturing Chemists' Assn., Inc., 1625 Eye St., N. W., Washington 6, D. C. $3.25.

The purpose of this book is to acquaint its reader with the properties which characterize the various commercially available plastics. It is hoped that by helping to focus the attention of engineers, molders and fabricators of plastics on the measured properties of these materials, a contribution may be made towards the development of that background of experience in the relationship between test results and field performance, which is a necessary basis for the accurate use of technical data for engineering design.

(Continued on page 379)

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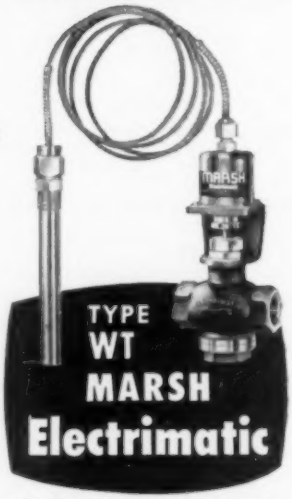

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Plastics of like base materials are subdivided into types. Types are modifications of basic composition designed to improve properties pertinent to various applications for which the base material otherwise would not be suitable or as suitable. In types, various pertinent properties are improved but other properties may remain unchanged or become inferior.

Materials essentially of a type may not be entirely alike in composition. There are, for example, heat-resistance, cold-resistant, impact-resistant, moisture-resistant types. Where further subdivision is desirable several grades are listed under each type. Whenever possible, the types and grades correspond to those given in the ASTM specifications. Subdivision to the point where specific materials are exactly described is impractical in this book because of the very large number of plastic compositions on the market. However, each grade does represent, at broadest, a very restricted number of common commercial materials which are quite similar both chemically and physically. The properties of laboratory freaks and of specialty materials that were tailored for unusual applications have not been included.

Automation in Business and Industry

Edited by EUGENE M. GRABBE, SR. *Staff Consultant on Automation, Computer Systems Div., The Ramo-Wooldridge Corp. 6¼ x 9¼ in., 611 pp. Published by John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N. Y. $10.*

Based on a series of lectures given by 21 prominent engineers and scientists at the University of California, the book covers fundamentals of automation, new developments in automation techniques, and descriptions of automation systems applications. The book describes how feedback control, instrumentation, analog and digital computation, and data processing are applied to control systems that encompass the range from individual machines to top management. Emphasis is placed on those applications of control systems which can perform both complex control functions and data processing. As a result, considerable attention is paid to electronics, computers, and data processing.

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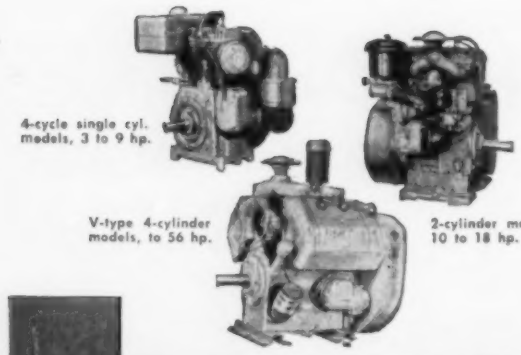
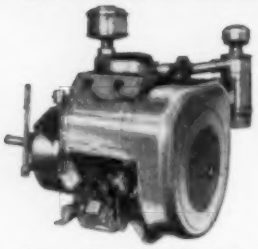


Torque Champs



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OUR READERS SAY . . . . . .

Letters should be addressed to the Editor, *Product Engineering*, 330 W. 42 St., New York 36, N. Y.

On "Controlling Temperature Rise"

To the Editor:

In the article, "Controlling Temperature Rise . . . in Induction-Motor Drives" in the Jan. 1957 issue, on page 172, bottom right column, the author states: ": . . it may be practical to use lower motor rpm with higher gear or V-belt drive ratio, and thus produce net reduction in heat for frequent starts or reversals." With a load having a high inertia relative to the motor, use of a lower motor rpm would gain little. —B. JOHNSON
Philadelphia, Pa.

Ed—The author replies: While Mr. Johnson's comment is a widely accepted view, it is not born out by the facts. A lower motor rpm will allow a higher number of starts or reversals per minute with the same temperature rise regardless of the ratio of load inertia to motor inertia.

For example: Assume a rotor inertia of 2 lb-ft² and a load inertia of 40 lb-ft², a 20:1 ratio. If, as in the article, we assume the rotor inertia is the same for both an 1800 and a 900-rpm motor, calculations based on Eq. 2 will show that the heat produced in the lower-speed motor is less than in the higher. Again, this assumes that the "design factor" $\left(1+\left[\frac{R_r}{R_l}\times C_1\right]\right)$ is the same for both motors. Actually, the greatest advantage is found in low-load speeds, rather than low inertias.

In the example above, assuming a 300 rpm load speed, the advantage in favor of the 900-rpm motor would be about 4:3 in terms of heat production. In addition, the lower speed motor frame is larger, and has more than twice the area for heat dissipation which allows it to run at a considerably lower temperature.

Perhaps we might also have emphasized the fact that substitution of a lower-speed drive motor would not be

(Continued on page 383)

Spraco full-cone, free-flow nozzle discharging 860 gpm at 5 psi. This photo was taken at 1/5000 sec. shutter speed . . . at this speed the pulsations of the pump are apparent in the spray pattern.

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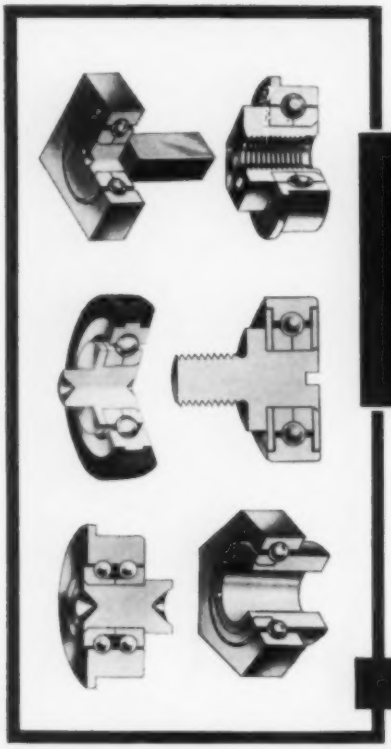

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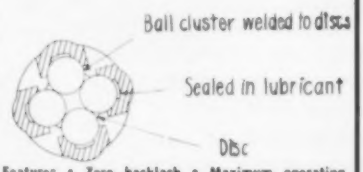

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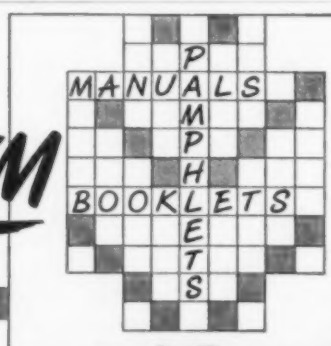

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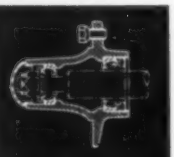

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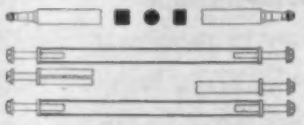

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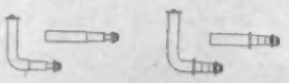

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particularly effective for loads requiring long starting times (over 5 sec), infrequently accelerating loads of high energy at top speed. The paragraph criticized did not refer to this type of drive, however, an article in the April 1956 issue, "Driving High Inertia Loads" covered that subject.

—C. C. LIBBY
Fairlawn, N. J.

Scientists, Engineers and Social Responsibility

To the Editor:

Your editorial in the March issue refers to the report of the American Association for the Advancement of Science which holds that scientists should be concerned with the social implications of their work; that scientists should inform the public of the consequences of scientific developments.

Scientists and engineers can take a further step in deciding to use their training and abilities only for constructive, not destructive work. What they say will ring with more sincerity if they do not themselves create things they warn against. Those who refuse to engage in destructive work have formed the Society for Social Responsibility in Science, primarily an American organization, but with members in 17 countries. —WALTER GORMLY
Mount Vernon, Iowa

Ed—We can well understand the conviction that guides the leadership for the Society for Social Responsibility in Science. It is true that at all times in history there have been men willing to convert new technical knowledge to selfish uses, and today is no exception.

It is the policy of *Product Engineering* to serve in the field of communication of technical knowledge; we must leave to other media, such as your organization, the responsibility for serving rallying point and means of those of a common mind on this ethical issue.

Data-Interval Number Series

To the Editor:

I would like to make a few comments about the article that appeared in the April issue of Product Engineering, "A New Data-Interval Num-

(Continued on page 385)

Idea!

room air conditioning unit using H & K perforated metals

In the ¾ ton window air conditioner illustrated, perforated metals have been combined successfully with injection moulded plastics. The utilization, here, of new louvered perforated metals in adjustable frames on the frounced surface in combination with new embossed patterns on sides and under surfaces, afford rich tactile qualities hitherto unattainable in the air conditioner field.

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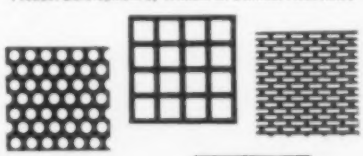

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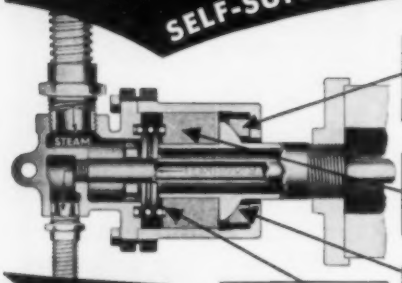

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ber Series." In the first place, the series is by no means new. It is merely one of the many series that can be formed from the 40 Renard numbers.

Using international notation, the series can be given the symbol R 40/20. This means that the series consists of every twentieth of the forty Renard numbers. Unless otherwise noted, it is assumed that the term begins with the number one, or a decimal of one. The notation R 40/20 can also be written R2.

The American Standard includes R 40/½, R 40, R 40/2, R 40/4, and R 40/8. These are called the 80 series, 40 series, 20 series, etc. The "doubling series" that Mr. Hottenroth mentions (1, 2, 4, 8, . . .) is the R 40/12 series.

In the paragraph beginning at the bottom of page 179, the ambiguous statement is made that the ASA series is a slow moving series, advancing in steps of 60%. This statement is correct only for the R 40/8 series. (The 5 series in the ASA standard.)

Number series, and in particular those built around the 40 basic Renard numbers, can be very useful in many design programs. It would be of great value to see a more thorough presentation of the subject than just an isolated fragment, especially since there is not much information on the subject in the literature of this country.

—Earlwood T. Fortini
Newton Highlands, Mass.

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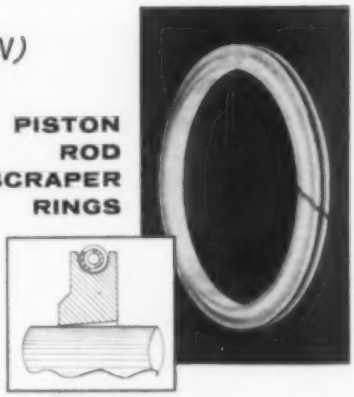

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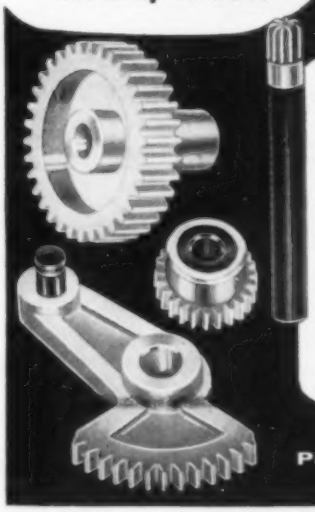

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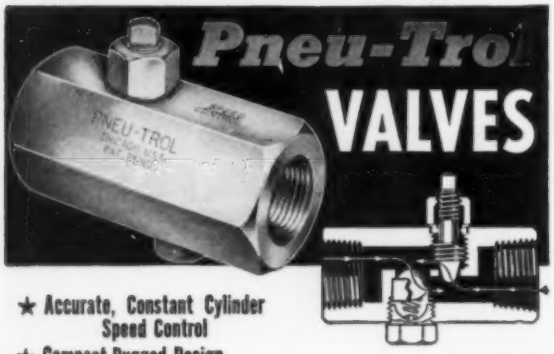

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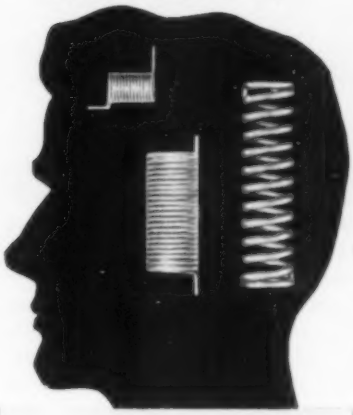

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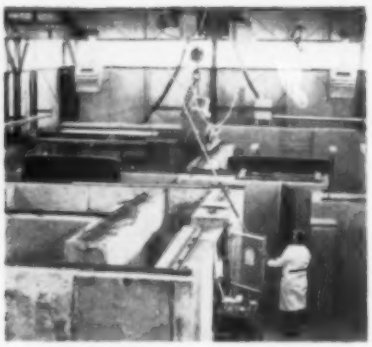

Betatron Installed in Castings Plant

A 24-million volt industrial betatron has been installed in the plant of Bonney-Floyd Co., Columbus, Ohio, manufacturers of steel castings. The unit is track-mounted and shuttles between two radiography rooms. Apertures in the end walls and precision positioning of the unit at either end of the track make it possible for the operators to set up castings for X-raying while previously set-up castings are being radiographed in the adjacent laboratory.

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(Continued on page 389)

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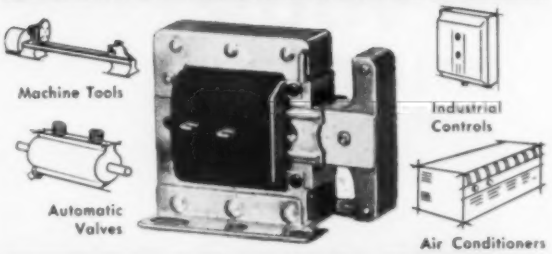

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floor space. It houses 40 chemical research laboratory modules, a special section for chemical engineering research, and offices. Approximately 160 personnel of the company's Inorganic Chemicals Div. will occupy the building upon completion.

Printed Circuits Soldered Without Dipping

A new technique for soldering printed circuits, developed by Fry's Ltd. in Britain, and shown by Electrovert Inc., New York, N. Y. early this month, eliminates the objectionable features of dip soldering and opens the way to automation.

Conventional method of soldering joints in printed circuits is by locating them all on one face of the board and dipping this face in molten solder, necessitating a reciprocating motion of the board and "angling" it in and out of the solder pot.

Heart of the new technique is the production of a stationary wave of molten solder by an impeller pump that accelerates the metal through a suitably shaped nozzle. As the crest of the wave is higher than the level of the container, it is possible to solder the underside of a board which travels straight across the molten solder wave.

Surplus solder metal falling back into the container carries with it flux residue, charred board particles, and undesirable oxides which collect in the trough of the wave, where they remain until skimmed off. High density of solder metal insures that these residues float on the solder bath, while location of impeller pump causes only clean metal to reach the board. The submerged impeller pump is is connected by a transmission to a variable speed motor, which makes possible a controlled height of solder wave.

Level of the bath is held constant by a device that feeds an ingot of solder into a melting chamber which heats it up to operating temperature and allows it to flow into the soldering pot. Temperature of solder metal is maintained automatically.

Use of this technique permits straight-line flow of printed wiring boards, accelerating production.

Other advantages claimed are: pos-

(Continued on page 391)

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Eastern Aviation Hydraulic Pumps are the smallest and lightest line of pumps ever made. They supply as much as one gallon of fluid per minute against pressures as high as 2000 PSI.

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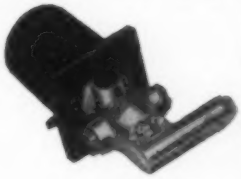

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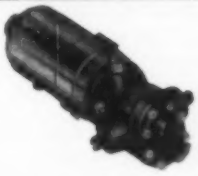

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Send for Aviation Bulletin 340

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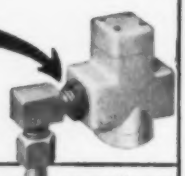

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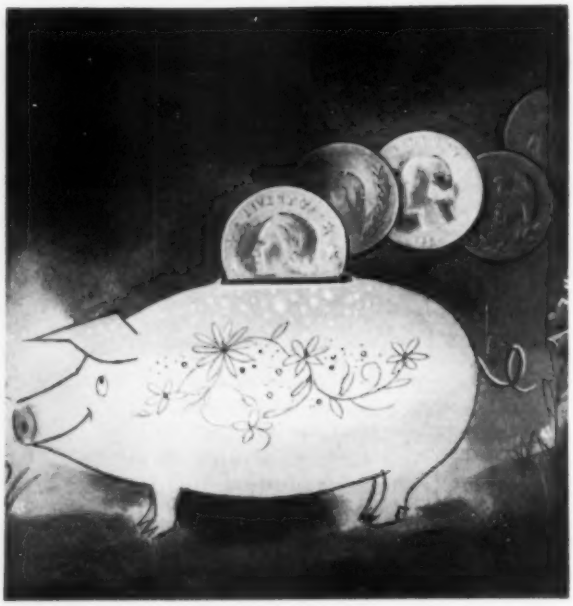

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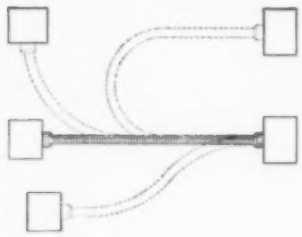

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B. F. Goodrich To Build Adhesives Plant

Plans for the construction in Akron, Ohio, of a $2.5 million specialized plant for the manufacture of adhesives were announced by the B. F. Goodrich Industiral Products Co. It will house production facilities, a development laboratory, and will employ approximately one hundred persons. Ground will be broken for the new building late this summer with completion scheduled for 1958.

Name Changes

Union Carbide and Carbon Corp. has shortened its name to Union Carbide Corp.

Linde Air Products Co., a division of Union Carbide Corp., has changed its name to Linde Co.

Electroplating Design, Inc., has changed its name to Bart Laboratories and Design, Inc., in order to reflect the affiliation with the Bart Mfg. Co.

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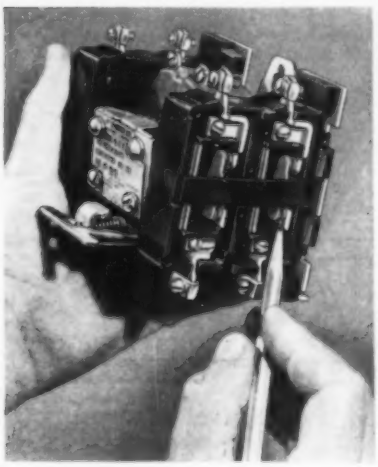
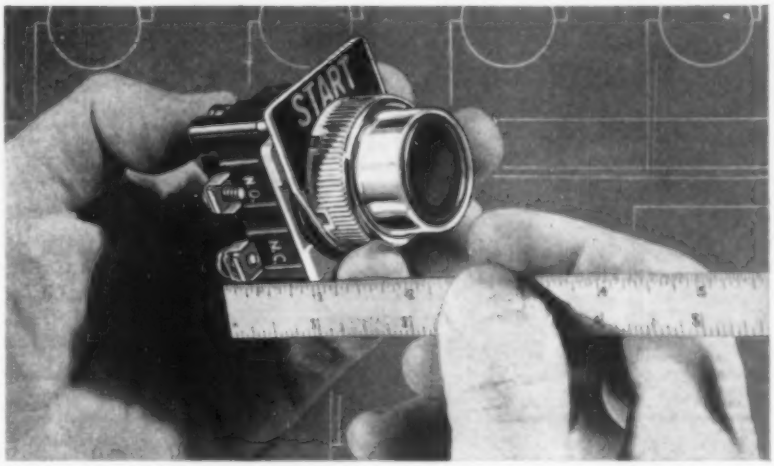
News for and about Panelbuilders

CONTACTS EASILY CONVERTED ON C-H MULTI-POLE CONTROL RELAYS, NO NEW PARTS NEEDED

Cutler-Hammer's 9575 family of multi-pole control relays was designed to facilitate simple, quick contact conversion. To convert a normally open contact to a normally closed contact, or vice versa, the stationary and movable contact members are simply reversed . . . no special parts or tools are required. Not only does the versatility of the 9575 control relay simplify on-the-job contact conversions, but also many panel builders prefer to stock their



Cutler-Hammer Relays by the number of poles and arrange the contacts to suit each specific relay application as the relay is drawn from stock. Cutler-Hammer 9575 Multi-Pole Control Relays are available from 2 to 8 poles. For further information write for Bulletin 9575.



Space Saving Heavy Duty Oil-Tight Control Units Provide Greater Circuit Flexibility

To meet the demand for smaller, more flexible heavy duty oil-tight pushbuttons, indicating lights and selector switches, Cutler-Hammer developed the 10250T family of control units. These units, adaptable for either one-hole mounting or base-mounting, offer amazing opportunities for simplified compact control panel design.

Back-of-Panel Depth—1 3/32"

Cutler-Hammer's pushbutton units are available as either flush button, extended button or mushroom head operators. When one-hole-mounted, a double pole pushbutton unit extends only 1 3/32" behind the panel. The double pole contact blocks are available in any combination of normally open and normally closed contact. Each circuit is mechanically and electrically isolated from the other. For additional circuits, contact blocks can be quickly tandem mounted. No special attachments required. Operators come in six distinctive colors.

Indicating Lights Include PresTest

Cutler-Hammer 10250T oil-tight indicating lights, either resistor type or transformer type, have 180 degree non-blinding lenses. These unusually compact lights are available in six brilliant colors, with either unbreakable plastic or heavy glass lens. PresTest, the famous self-testing indicating light, permits instant checking for faulty bulbs without dismantling the unit. Merely by pressing on the PresTest lens, the bulb is disconnected from the normal circuit and checked on a separate test circuit.

Roto-Push—The One-Button Control Station

Cutler-Hammer's Roto-Push is a single unit that combines the functions of the push-button and selector switch. Available in either two or three position types, the guard ring rotates to select the desired function while the push-button actuates the circuit. Roto-Push offers practically unlimited circuit combinations and often it will replace two or three units. Cutler-Hammer's 10250T family also includes a complete line of two and three position selector switches in a variety of operators.

C-H Master Design

For complete information of Cutler-Hammer's 10250T family of control units write on your company letterhead for C-H Master Design, Pub. EL-178.

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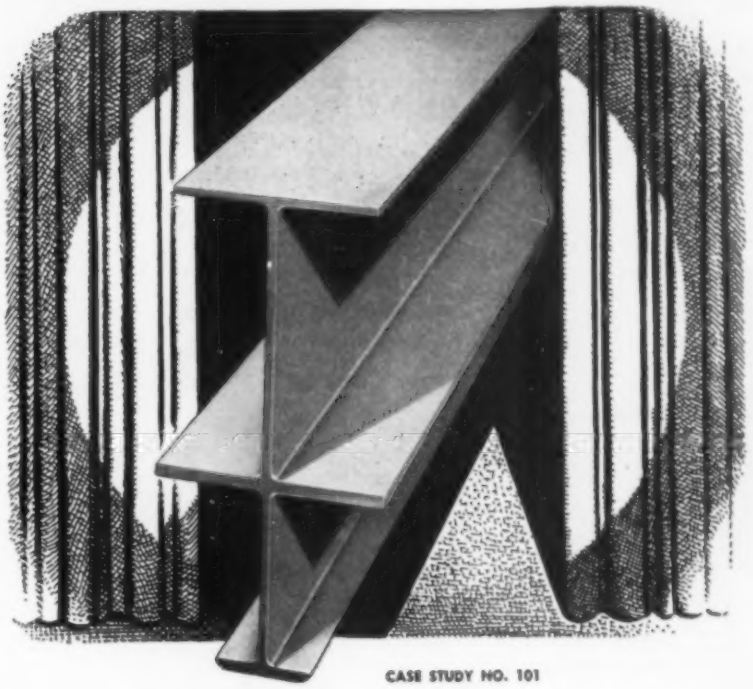

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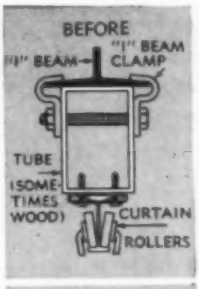

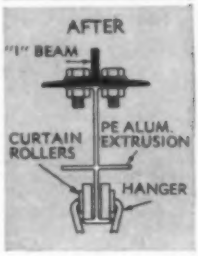

Art Drapery Studios, 2739 N. Racine Ave., Chicagoland designers and installers of stage curtains and gymnasium dividers, had a track problem—and tracks are an important part of any job they do. Over-all costs were high because of drilling, assembling, splicing, and installation operations.

THE PROBLEM AND SOLUTION

Could Precision Extrusions, Inc. design a one-piece extruded aluminum track that would solve these problems? As illustrated, PE engineered a track that eliminates drilling, assembling, and splicing operations; simplifies installation; makes it easy to curve the track right on the job. In addition, both material and labor costs are cut 50%.

*** WHAT IS EXTRUSIONEERING?**

"Extrusioneering" is a PE *plus* service designed to assist you in developing new ideas to solve specific problems, to cut manufacturing costs, and to improve product quality.

Most likely your need is far removed from curtain tracks; but why not call in a PE engineer and let him work with you towards a solution to *your* problem—whatever it is. There is no obligation.

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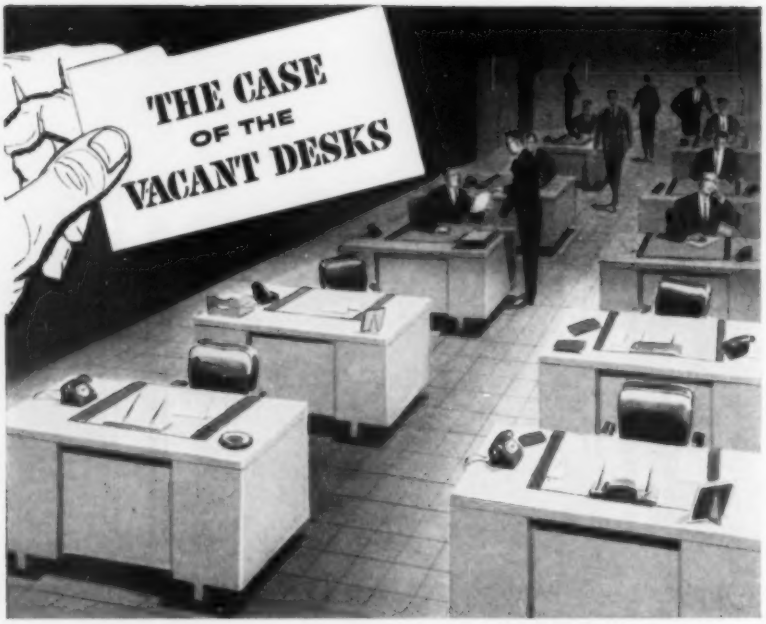
Chicagoland's Oldest Aluminum Extruder



WHENEVER we see the desk of one of our Field Engineers vacant, it's a good sign. Chances are, he's on a trip, making calls with Foote Bros. Distributor personnel—helping solve a power transmission problem *in the field*. That's why we call them Field Engineers.

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FOOTE BROS. GEAR AND MACHINE CORPORATION

4575 South Western Boulevard, Chicago 9, Ill.

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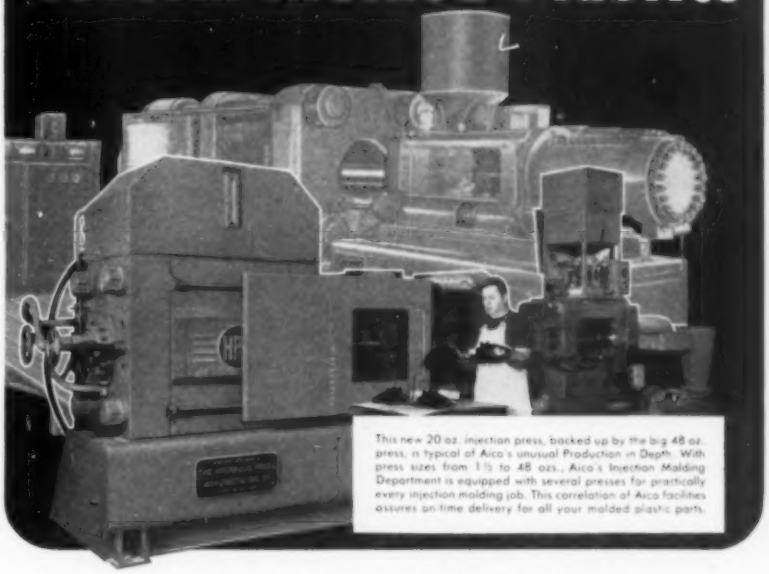

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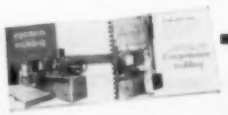

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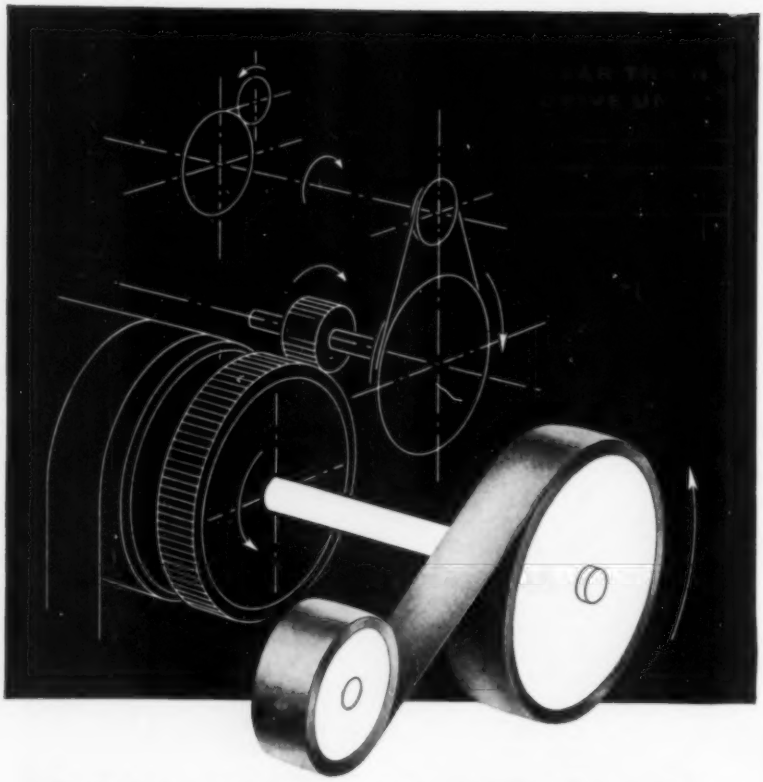

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CONTROLLER
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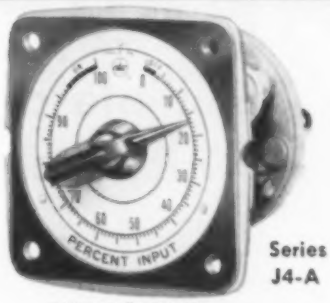
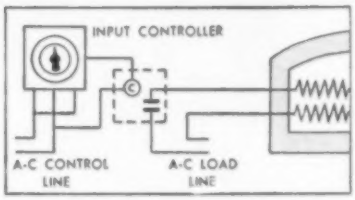


Series J4-A

ONLY 3⅛" SQUARE

When your electrically heated equipment needs less than full current, you set the Atcotrol Input Controller to the per cent of input you need and the controller automatically delivers the required heat without any waste. The standard unit operating on a one-minute time cycle can, for example, provide a 60% input by causing the current to be on for 36 seconds and off for 24. Resistance elements which overheat and need frequent replacement are thereby eliminated.

Also used on heaters, dehumidifiers, evaporators, driers, filters, presses, pumps, filling operations and other applications.



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Big, ⅜" diameter silver-load contacts are self-cleaning and quick breaking. Rated capacity is 25 amperes at 115 volts a-c, 20 amperes at 230 volts a-c, non-inductive load.

MOUNTING AND SERVICING FEATURES

Standard model (shown above) is mounted to panel by four screws. Deluxe model with plastic cover (similar to timers at lower left) requires no mounting screws. Synchronous motor needs no lubrication. Simple removal of sleeve housing provides quick access for inspection. Nylon cams and gears assure quiet operation. One piece mold fiberglass reinforced, back plate includes semi-circular terminal block. Each terminal protected by 270° arc barriers. Compact construction: 3¾" square by 4 11/16" behind panel.

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Stop cycle, automatic reset.

D-C TIMERS
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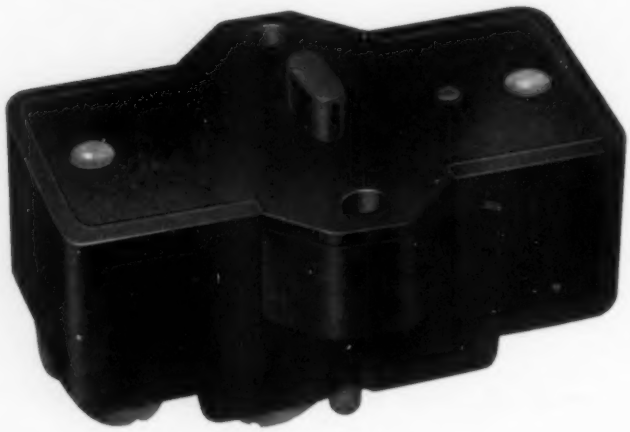
HEAVY DUTY
multiple circuit switch for machine tools



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LONG LIFE—Many millions of cycles mechanical life. Consult factory for maximum electrical life.

SCREW TERMINALS—Easy installation.

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242-0005-03	Double Circuit 1 Closed 1 Open	4
242-0013-03	Double Circuit Normally Closed	4
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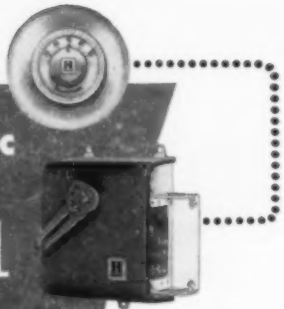
MINNEAPOLIS Honeywell Zone Controls



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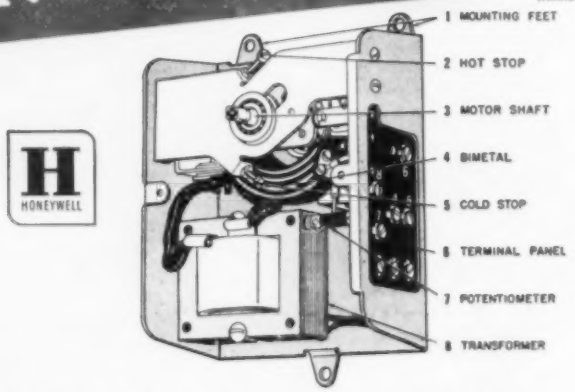

The Honeywell Round (or any of the other M-H room thermostats) and the M829A Damper Control are among the controls that provide a modulating air volume zone re-balancing for forced air heating and cooling systems. Your residence now may have three or more such zone controls to compensate for changing conditions such as outdoor temperature, wind direction and velocity, solar radiation, cloudiness, etc. Constant comfort may now be yours at all times in recreation room, attic, living room, sleeping areas, or distant wings. Chace bimetal actuates these controls.

The M829A Damper Control does NOT open and close the duct dampener each time the room thermostat calls for heat. The Chace Thermostatic Bimetal element makes and breaks the contact at intervals determined by the heating requirements of the zone. In colder weather the ON time increases. Thus the percentage of time the circuit to the Damper Control is closed increases in proportion to the heating load. Current flowing for shorter or longer intervals through the bimetal coil element produces heat which causes the bimetal to expand and rotate the damper shaft. If less heat is needed in the zone, the damper "floats" slowly back and forth near the closed position. If near maximum heat is needed, the damper "floats" near the wide open position. The burner operation is controlled by a T835A Outdoor Reset Control whose two remote bulb elements maintain plenum temperatures proportional to outdoor temperatures.

Remember Chace when you design for temperature actuation or indication, or for protection of valuable equipment. Dependable Chace Thermostatic Bimetal is available in 28 types, in strip, coil or completely fabricated and assembled elements made to your specification. Write for new 44-page booklet, "Successful Applications of Chace Thermostatic Bimetal," containing interesting uses of bimetal and many pages of engineering data.

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1607 BEARD AVE., DETROIT 9, MICH.

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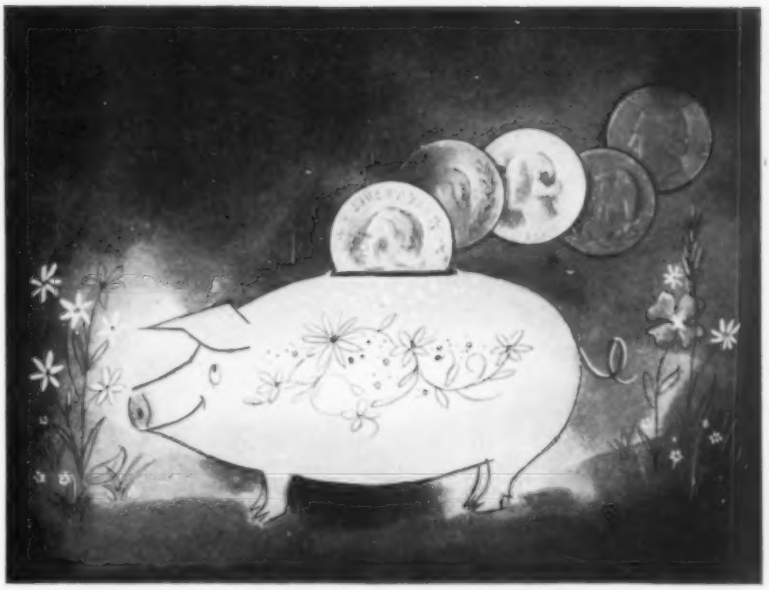

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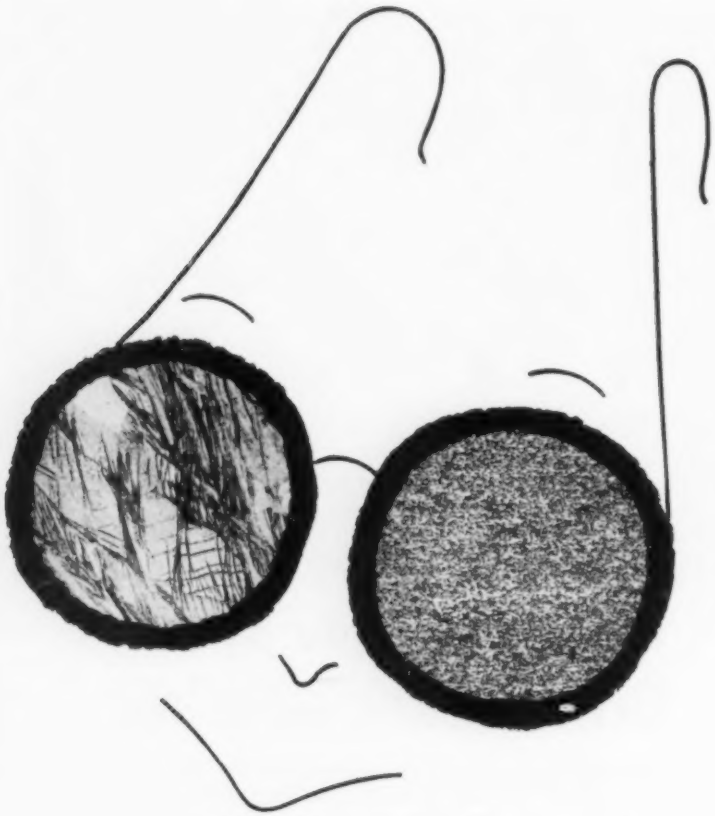

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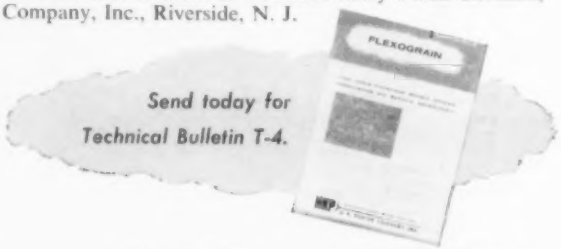

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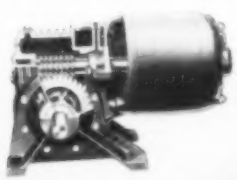

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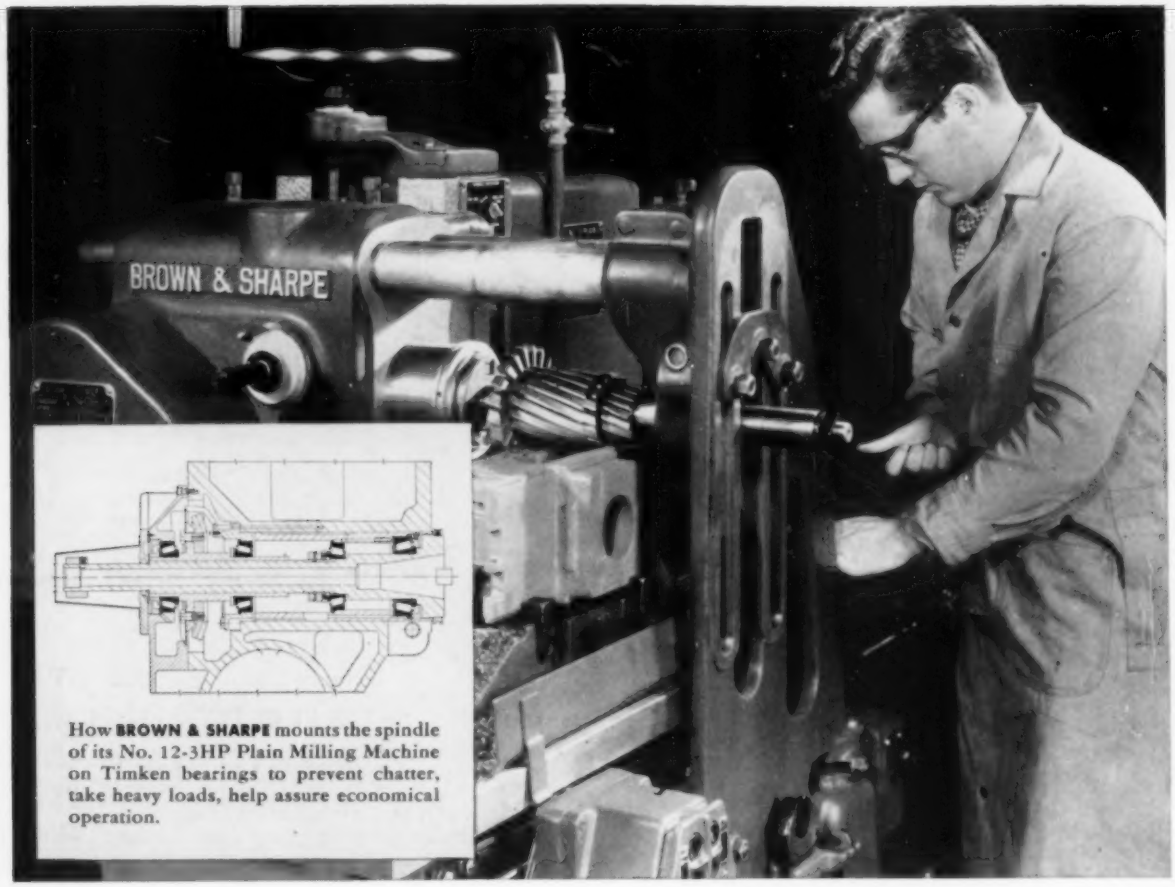

How **BROWN & SHARPE** mounts the spindle of its No. 12-3HP Plain Milling Machine on Timken bearings to prevent chatter, take heavy loads, help assure economical operation.

Climb mills both ways . . . TIMKEN® bearings prevent chatter in heavy cutting

TO make heavy cuts without chatter, Brown & Sharpe mounts the spindle of its No. 12-3HP Plain Milling Machine on two Timken® tapered roller bearings. For smooth power transmission, they use four Timken bearings in the bevel gear drive to the spindle. And to take climb milling's pulsating loads, two Timken bearings are used in the feed screw drive. Result—production milling is fast and accurate. Here's why.

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Timken bearings hold the spindle in positive alignment. Their tapered design lets them take *both* radial and thrust loads in any combination. And full line contact between rollers and races gives Timken bearings extra load-carrying capacity.

• HEAVY LOADS ABSORBED

Rollers and races on Timken bearings are case-carburized to have a hard, wear-resistant surface over a tough, shock-resistant core. They take heavy loads and come back for more.

• FRICTION VIRTUALLY ELIMINATED

Timken bearings are geometrically designed to have true rolling motion and are precision-made to live up to their design. Practically friction-free, they last longer and run smoother. And to assure complete quality control, we even make our own electric furnace fine alloy steel. No other American bearing maker does. So for your No. 1 bearing value, always specify bearings trade-marked "TIMKEN". The Timken Roller Bearing Company, Canton 6, Ohio. Canadian plant: St. Thomas, Ontario. Cable address: "TIMROSCO".

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